THE EAR;

ITS ANATOMY, PHYSIOLOGY, AND DISEASES:

A PRACTICAL TREATISE

FOR THE USE OF

MEDICAL STUDENTS AND PRACTITIONERS.

BY

CHARLES H. BURNETT, A.M., M.D.,

AURAL SURGEON TO THE PRESBYTERIAN HOSPITAL; SURGEON IN CHARGE OF THE
INFIRMARY FOR DISEASES OF THE EAR, PHILADELPHIA.

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PREFACE.

In view of the great advances which have been made of late years in Otology, and of the increasing interest manifested in it, the Author has felt that the profession might welcome a new work which should present clearly but concisely its present aspect, and should indicate the direction in which further researches can be most profitably carried on.

Such a work it has been the Author's aim to produce, and in accomplishing the task it will be seen that he has freely availed himself of the observations and discoveries of others. These he has, as far as practicable, tested by his own experience in the opportunities afforded by several years' special devotion to the study of the diseases of the ear.

Considerable practice in teaching has shown him that the pathology and therapeutics of the ear cannot be properly understood without a more intimate acquaintance with its anatomy and physiology than is afforded by the ordinary text-books. In these departments much important work has recently been done abroad, especially in Germany, and the author is confident

that the space which he has devoted to their consideration will not be considered as excessive.

In conclusion, he trusts that, although the work is primarily designed for the student and general practitioner, it will not be found devoid of interest for the specialist.

CHARLES H. BURNETT.

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    Philadelphia, September, 1877.

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ERRATA.

Page 73, 13th line from bottom, *for* Fig. 18, *e*, *read* Fig. 17, *e*.
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PART I.

ANATOMY AND PHYSIOLOGY.

SECTION I.

EXTERNAL EAR.

CHAPTER I.

THE AURICLE.

ANATOMY.

The external ear comprises the auricle and the external auditory canal. The auricle, or ear of common language, is formed of a cartilaginous sheet, from one to two millimetres thick, with various depressions and elevations. Extrinsic and intrinsic ligaments and muscles are inserted into it; it is well supplied with bloodvessels, lymphatics, and nerves; and it is covered with skin.

The auricular cartilage is of the reticular variety, and the various depressions and elevations into which it is twisted have received the following names: helix, antihelix, fossa of the helix, fossa of the antihelix, the tragus, the antitragus, the lobule, and the concha. The entire auricle is also called the pinna. These portions of the auricle have received other names from some authors, but those given here are, perhaps, the most commonly used in English. Henlé and others give to the fossa helicis the name of fossa navicularis or scapha, and to the fossa antihelicis the name of fossa triangularis. I prefer, however, the names suggested by Gray, because they will naturally occur to any one acquainted with the anatomy

Fig. 1.
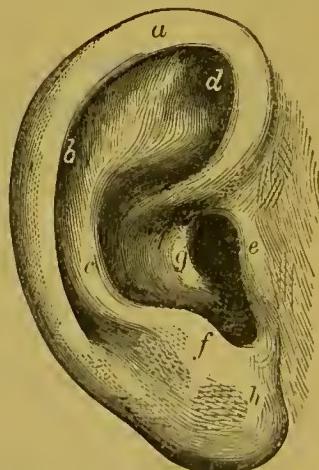
The Auricle.—a. Helix. c. Antihelix. b. Fossa of the helix. d. Fossa of the antihelix. e. Tragus. f. Antitragus. h. Lobule. g. Concha.

of the auricle, and the combination of a few words will supply the terms necessary in the designation of the various parts of the pinna.

Fig. 2.
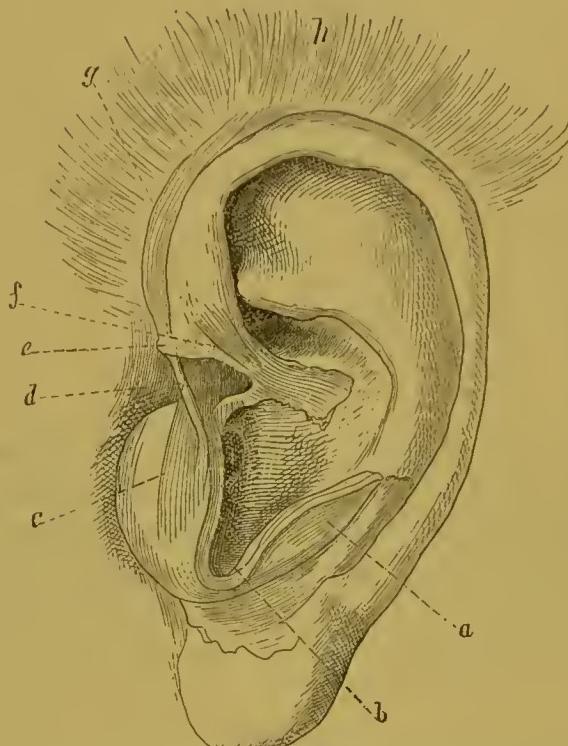
MUSCLES OF THE AURICLE, Outer Surface. (Henlé.)—*b*. Incisura auris. *e*. Spina helicis. *h*. M. auricularis superior. *g*. M. helicis major. *f*. M. helicis minor. *c*. M. tragicus. *a*. M. antitragicus.

Muscles of the Auricle.—The extrinsic muscles of the auricle are those which move it as a whole, and are the

<div style="text-align:center">

I. Attollens aurem.

II. Atrahens aurem.

III. Retrahens aurem.

</div>

The intrinsic muscles of the auricle, or "proper muscles of the ear," are seven in number. These have also been denominated *vestigia*, a name well-chosen as indicative of their condition in man.

Henlé says:[1] "These muscles, with one exception, run between the various portions of the auricular cartilage and the external auditory canal. They are all muscles of animal life; but on

[1] Eingeweidelehre, s. 726.

account of their extreme thinness are pale, and lie immediately upon the cartilage, into the fibrous layer of which they are inserted by means of short tendinous fibres. They are not equally persistent; whether they are all equally developed at first and finally become atrophied through disease, can only be decided by a statistical comparison of the ears of adults and children."

Five of the proper muscles of the auricle are on the anterior surface and two are on the posterior surface of the organ. Those on the anterior surface of the auricle are the *tragicus*, the *antitragicus, helicis major, helicis minor*, and the two on the posterior surface are the *transversus auriculæ* and the *obliquus auriculæ*.

Fig. 3.
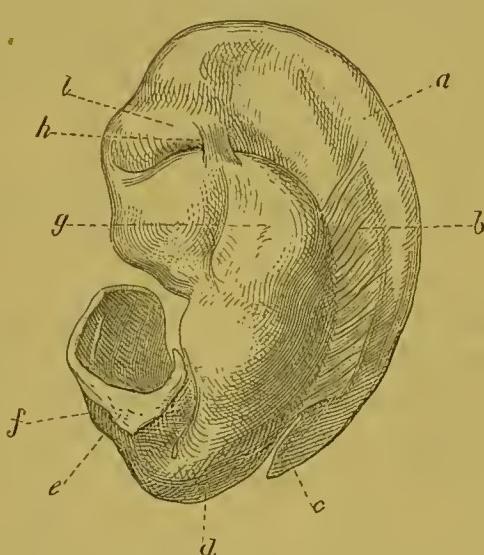
CARTILAGE AND MUSCLES OF AURICLE, Posterior View. (Henlé.)—*f*. Cartilage of externa auditory canal. *e*. Surface of attachment of same to the edge of the bony canal. *d*. Cartilage of the pinna. *c*. Canda helicis. *l*. Eminentia scaphæ. *g*. Eminentia fossæ conchæ. *h*. Transverse muscle of the auricle. *b*. Oblique muscle of the auricle.

In some rare cases, a third muscle is found in the auditory canal, and is called the *M. incisuræ Santorini*. It lies below, and further in the auditory canal than, the M. tragicus.

Ligaments of the Auricle.—The ligaments of the auricle may also be divided into an extrinsic and intrinsic set: The first connect the auricle with the side of the head, and the second connect the various parts of the cartilage together. The former, the most important, are two in number, anterior and posterior.

The anterior ligament extends from the process of the helix to the root of the zygoma. The posterior ligament passes from the posterior surface of the concha to the outer surface of the mastoid process of the temporal bone. A few fibres connect the tragus to the root of the zygoma.

"Those connecting the various parts of the cartilage together are also two in number. Of these, one is a strong fibrous band, stretching across from the tragus to the commencement of the helix, completing the meatus in front, and partly encircling the boundary of the concha; the other extends between the concha and the processus caudatus."[1]

Bloodvessels and Lymphatics of the Auricle.—The arteries supplying the auricle are, the *posterior auricular*, from the external carotid; the *anterior auricular*, from the temporal; and the *auricular branch*, from the occipital. The veins follow the arteries in their general distribution.

The auricle is supplied with a beautiful and very rich network of capillary lymphatics, an important consideration in aural disease.

Nerves of the Auricle.—The nerves are most numerous on the posterior surface of the auricle, while the concave surface and the lobule are comparatively poorly supplied with nerves.

In some of the lower animals, the mole variety especially, the nervous supply of the auricle is so rich and so peculiar in its development, as to endow the auricle with valuable tactile powers.[2] The nerves of the auricle are derived from the *auricularis magnus*, from the cervical plexus; *the posterior auricular*, from the facial; the *auricular branch of the pneumogastric;* and the *auriculo-temporal* branch of the inferior maxillary nerve.

Integument of the Auricle.—The cutis of the auricle is a continuation of that of the face and head, which, after covering the cartilage, forms a fold at its base, called the lobule.

In some rare instances the cartilage of the auricle may extend into the lobule, and then the usually harmless operation of piercing it for purposes of adornment may give rise to serious chondritis.

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[1] Gray's Anatomy, p. 629.   [2] Max Schultze's Archiv, 1870.

The auricle is abundantly supplied with sebaceous glands from 0.5 to 2.0 mm. in diameter, which are most numerous and highly developed in the concha. The entire surface of the pinna or auricle is covered with downy hairs, which attain their most luxuriant growth near the meatus and on the tragus, to which fact the latter spot owes its name of "goat" or tragus.

Sudoriferous Glands.—The sudoriferous glands are most abundant on the posterior surface of the auricle, an important consideration in the management of the ears of infants, for if their auricles are pressed constantly against the head, as is too apt to be the case, chafing of the parts must be the inevitable result.

The modified sudoriferous glands of the cutis of the external ear are developed into ceruminous glands in the external auditory meatus.[1]

PHYSIOLOGY.

The use of the extrinsic auricular muscles is usually very imperfectly developed in man, although the ability to move the auricle is now and then met with even in the most cultivated. It has, however, been supposed, that as civilization has elevated man above a merely animal existence, the power to move the auricle freely and voluntarily, has diminished as the necessity of such a function would cease with a less savage life.

Such indeed seems to be the rational view to take of the use of these muscles. That they are capable, however, of cultivation does not seem to be an uncommon observation. All are familiar with the story of Albinus, the anatomist of the eighteenth century, who could move his auricles so well, that he was in the habit of removing his wig in order to demonstrate to his class the power he possessed over them.

Sir Astley Cooper has recorded a case[2] in which the auricles were in constant motion whenever great attention was necessary. Two physicians of my acquaintance can move the auricles markedly with ease. I have very often seen the auricles move unconsciously in my patients, when standing behind them, and they were obliged to be more than usually attentive. But this motion was not continual; it appeared to me to be an entirely

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[1] Kessel, Stricker's Handbuch, p. 841.   [2] Phil. Trans., London, 1800.

involuntary endeavor at an adjustment of the auricle in the most advantageous position for hearing. When suddenly surprised by an unusual or loud noise, I am sensible of a very marked movement, entirely involuntary, of my own auricles.

I have seen marked contraction in the region of the tragicus and anti-tragicus muscles, during the application of the constant electric current by means of a ball-electrode.

The general opinion is that a small ear, well shaped, is a sign of careful breeding, whereas the large elephantine auricle is accepted as a type of vulgarity;[1] however, the unfortunate possessor of a large auricle is compensated for his so-called misfortune, by the popular belief that the large auricle is a sign of good nature and generosity. This may be the modern idea, but Giotto, in his drawing of Envy, in the chapel of the Arena at Padua, represents the auricle as superhuman in size, its long axis as a continuation of that of the horizontal ramus of the inferior maxillary bone, and without a lobule.

It is also a matter of interest that the position and shape of the auricle are national peculiarities, as seen on the ancient Egyptians, the trait being carefully preserved even in the rude attempts at works of art made by the artists of the age and country. It is also said that the Egyptians, even in the present day, possess this peculiarity of high-placed auricles, and as late as 1840 there was in " Paris a teacher of Arabic—a Copt of Upper Egypt—who possessed this conformation in a most decided degree."[2]

However significant the shape of the auricle may be, it is probably not so significant of *caste* as the shape and texture of the hand, although, without doubt, it has a great significance.

Prof. Meyer[3] states, that it has already been noted by previous observers that malformations of the external ear are found in the greatest number in connection with arrested development in the region of the first (Kiemenspalte) branchial or visceral fissure, viz., with cleft palate, and other forms of retarded development in the bones of the head and face. The explana-

[1] Parvæ malos mores docent, magnæ et erectæ indices sunt stultitiæ aut loquacitatis. Opera Galeni, iv. 797. Kühn, Leipsic, 1833.

[2] J. Williams, Treatise on the Ear, London, 1840, p. 80.

[3] Ludwig Meyer, Ueber das Darwinische Spitzohr. Virchow's Archiv, Band 53, Heft 4.

tion of Virchow, that these changes are due to inflammatory
processes in the earlier days of fœtal development, seemed
sufficient to Meyer, until, as he says, he instituted a careful
examination of the form and position of the external ear, in a
number of insane people, manifesting those peculiarities de-
scribed and called by him cranium progenicum. In all these
cases there was a relative arrest of development of the bones of
the face, especially a malformation of the inferior maxilla, and
it should be borne in mind that the inferior maxilla is formed
through ossification in the membrane of the visceral arch.
The expectation of finding, in just such cases, characteristic
forms of the ear, was not realized, and the theory appeared the
less tenable, the further the investigation was extended to
numerous cases of both the insane and the sane. Pathologi-
cally, the result of the investigation is considered by Meyer to be
unimportant, but he expresses a belief that the significance of
the form and position of the external ear is purely of a physiog-
nomical character.

In connection with a beautiful, well-formed face, we usually
find a round, well-formed, small, and close-lying ear; whereas, in
macrocephalic heads we find large massive ears, in some cases real
elephantine ears; while the narrow ear, directed backward, the
so-called Faun's ear, accompanies a low, retreating forehead,
sharp nose, and narrow chin. A comparative examination of
normal male heads seems to indicate that the position of the
ear possesses a certain and constant relation to the architecture
of the skull, for female heads, with a large facial angle, show
a more vertical position of the concha than is usually seen in
females and in children who possess, as a rule, small facial
angles.

In women and children we often find, in connection with a
large facial angle, obliquely placed ears, so that the upper part
of the helix points backward, and the posterior portion is
directed downwards. The cause of this is to be sought for in
the relation of the *ramus* to the body of the inferior maxilla
rather than in the relations of the superior maxilla and the
frontal bones to each other. The explanation of the connection
between the position of the ramus of the inferior maxilla and
the external ears is to be referred to the development of those
portions of the face from the same part of the *branchial arch*.

Not only the position of the ears, but the elevations and depressions of the auricle, vary even in the same individual.

Mr. Darwin's ideas of the significance of certain prominences in the helix are thus given by that distinguished observer: " The celebrated Mr. Woolner informs me of one little peculiarity in the external ear (*i. e.*, auricle) which he has often observed both in men and women, and of which he perceived the full signification. His attention was first called to the subject while at work on his figure of Puck, to which he has given pointed ears. He was thus led to examine the ears of monkeys, and subsequently, more carefully, those of man. The peculiarity consists in a little blunt point, projecting from the inwardly-folded margin, or helix . . . . These points not only project inward, but often a little outward, so that they are visible when the head is viewed from directly in front or behind. They are variable in size and somewhat in position, standing either a little higher or a little lower; and they sometimes occur in one ear and not in the other. Now, the meaning of these projections is not, I think, doubtful; but it may be thought that they offer too trifling a character to be worth notice. This thought, however, is as false as it is natural. Every character, however slight, must be the result of some definite cause; and if it occurs in many individuals, deserves consideration. The helix obviously consists of the extreme margin of the ear folded inward, and this folding appears to be in some manner connected with the whole external ear being permanently pressed backward. In many monkeys which do not stand high in the order, as baboons and some species of maccaus,[1] the upper portion of the ear is slightly pointed, and the margin is not all folded inward; but if the margin were to be thus folded, a slight point would necessarily project inward and probably a little outward. This could actually be observed in a specimen of the *Ateles beelzebuth* in the Zoological Gardens; and we may safely conclude that it is a similar structure—a vestige of formerly-pointed ears —which occasionally reappears in man."[2]

[1] See also some remarks and the drawings of the ears of the Lemuroidea in Messrs. Muril's and Mivart's excellent paper in Transact. Zool. Soc., vol. vii. pp. 6 and 90, 1869.

[2] Darwin, Descent of Man, vol. i. pp. 21 and 22.

Prof. Ludwig Meyer,[1] in an article referring especially to Darwin's idea, that the common, small projections in the helix of the ear are remnants of the pointed ear of certain Simian races, says that too much importance has been attached to the deviations in the form of the auricle, but he admits that frequently we find irregularities in the edge of the helix. To one of these, more prominent than the others, Darwin has attached the significance already alluded to. Now, the edge of the helix is rarely completely smooth, and even when any slight inequality of the concha escapes the eye, the finger can readily detect it. These are really deficiencies and not absolute prominences, and the wider the loss of substance in the helix cartilage, the more prominent will the remaining portions appear.

If, in an ear where one or two such prominent remnants of the helix occur, a line be drawn joining them, it will correspond with the outline of the normal helix. That these prominences are nothing more than remnants of the helix, is proven by the fact that their inclination and curve correspond entirely with the curve of the helix.

That part of the helix which affords the most examples of the peculiarity referred to by Darwin, is most adapted to producing the longest points, since it is the widest portion of the curved helix. These changes in the ear are doubtless not produced during life, but are congenital. They are found in perfection in little children, and are more apt to occur in males than in females. According to Kollman, the helix is not a separate point of development. The auricle consists originally of those formative parts which can be distinctly recognized at the end of the sixth week of foetal life, as tragus, antitragus, and antihelix. From the latter the helix is developed. Hence we see that as interferences in the development of the tragus may cause the presence of a cleft in it, so may disturbances in the development of the antihelix cause deficiencies in the helix.

Prof. Laycock says:[2] " Men of high intellectual attainments, great capacity for mental labor, and great force of character, have a full, perfectly ovoid ear, the helix well developed, the

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[1] Ludwig Meyer, Ueber das Darwinische Spitzohr. Virchow's Archiv, Band 53, Heft 4.

[2] Med. Times and Gazette, March 22, 1862. London.

lobule plump, pendent, and unattached to the cheek at its ante-
rior margin. These characteristics are seen in all portraits of
great men which Lavater gives, and are easily observed in liv-
ing celebrities."

The same writer also says: "In a perfect ear the ovoid lobule
hangs from the cartilage with a rounded lower margin, which,
at its inner border, is not confluent with the face. Now, if
this inner margin be adherent to the cheek, and at the same
time the lobule be only a segment of an ellipse, there is more
or less tendency to imperfect cerebral action. A more import-
ant form is seen when the lobe is not only soldered to the
cheek, but its posterior half cut away, as it were, and the helix
defective."

A knowledge of these peculiarities in the ear of an individual
may become of great legal value, as in the Tichborne case, in
which it was shown that the "claimant's" ears were altogether
different from those of the lost heir.

Comparative Functions of the Auricle.—The functions of the
auricle are modified by the habits of the animal, and, since in
most four-footed mammals the external ear is well developed,
we have an opportunity of observing in them a variety of func-
tions, acoustic and otherwise, acquired by the *auricle.* The
large, long, and easily moved auricles are found in animals that
are timid and often pursued by stronger and sagacious animals,
while those which pursue, as lions, tigers, etc., possess auricles
which are short and directed forwards.

We have no positive means of finding out how sounds are
modified by these peculiarities in the auricles of these animals.
However, by applying a variety of speaking trumpets to our
ears, and by alterations in the position of these artificial auri-
cles, as well as of our own by manipulation, we may form at
least an approximate idea of the modification in hearing pro-
duced by the size, shape, and position of the auricle. By such
experiments we see that it is highly probable that ordinary
sounds are augmented, and faint sounds rendered very audible
to animals with largely developed auricles, by the increased
resonance such organs produce, a function of the auricle useful
to animals which are rapacious as well as to timid ones which
are pursued.

The auricle is small in seals, walruses, moles, and the manis, but largely developed in some species of the bat, and "is so constructed as to prevent air from rushing in while flying."[1]

In birds, the auricle is wanting, as it would probably greatly impede their flight, but in night birds, the power to elevate the feathers around the ear seems to indicate that they can supply themselves at will with a kind of auricle, and that their hearing is thereby augmented, a necessity due to their nocturnal pursuits.

The auricles of the mouse[2] and of the hedgehog[3] are developed into organs of touch, and the auricles of marine mammals seem to become almost useless; as in the narwhal "the opening of the ear is of the diameter of a knitting-needle,[4] and in the leopard seal the ears are merely openings in the surface of the skin, which are placed one and a half inches behind the eye,"[5] while in the sea-otter[6] the "ears are less than an inch in length," the animal being at least five feet long.

In the water-shrew, an aquatic mammal, the anti-tragus serves as an operculum to the auricle, which fact seems to indicate that the auricle is no longer needed for hearing as soon as the animal ceases to live in the air. In the crocodile, also, the auricle acts as an operculum, and in the whale it is practically absent. Therefore, the fully developed auricle is needed by and found in mammals whose life and condition are aërial, and we find that it ceases to exist, or its functions are altered, in mammals inhabiting the water or living underground.

So much influence on hearing was attributed to the auricle by the first Dionysius of Syracuse, that he is said to have constructed a subterranean cave in a rock, in the form of a human ear, which measured eighty feet in height and two hundred and fifty feet in length; the sounds of this cave were then directed to a common tympanum, which had a communication with an adjoining room, where Dionysius spent the greatest

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[1] J. Williams, Treatise on the Ear, London, 1840, p. 35.

[2] J. Schöbl, Max Schultze's Archiv f. Mic. Anat., 1871, p. 260, four plates.

[3] Ibid., 1872, p. 295.

[4] Marine Mammalia of North America, by Chas. M. Scammon, U. S. Rev. Marine, p. 108.

[5] Ibid., p. 165.   [6] Ibid., p. 168.

part of his time, to hear whatever was said by those whom his suspicions and cruelty had imprisoned.

Resonant Functions of the Human Auricle.—As early as 1840, J. Williams, M.D., of London, attributed to the "configuration and tension of the auricle" the function of determining the "finesse of hearing." This author was led to such a conclusion by the augmentation of sound obtained by pressing forward the auricle, and surrounding it by the hand, but he mistakenly referred the improved hearing which ensued to the overcoming of what he termed a relaxed condition of the auricle by the support of the hand. It was, on the contrary, due to the augmented resonance of the auricle, brought about by the relative lengthening of the external ear, by pushing the auricle out from the head, and adding to it the resonance of the hand. It is evident, therefore, that writers on the ear long ago noted the phenomena of alteration in the resonant functions of the external auditory apparatus caused by increase or diminution of its depth and position; but that these phenomena depended upon the power of the auricle and the external auditory meatus to act as resonators was not suggested nor proven until Hemholtz's experiments in acoustics had rendered the subject of resonators clearer, and experiments on the human ear demonstrated that the most probable function of the auricle is that of a resonator, adapted to augment just those *high* notes or sounds most likely to be of interest and importance to man.

According to Dr. Küpper,[1] the auricle can reflect sound into the auditory canal only to a limited extent, "because that part of the auricle which would reflect the sound-wave falling on it, into the auditory canal, is very small." Nor does he believe that it is concerned in the direct collection and transmission of sound as the drum-head is, for it is neither so elastic as the latter, nor is it inserted into a bony frame. He also denies it the function of determining the direction of sound, which, he thinks, may be proven by inserting into the meatus, a tube of any kind, thus cutting off all participation of the auricle in the reception of sound, when it will be found that the direction of sound can still be told.

[1] Archiv f. Ohrenh., vol. viii. 158.

This author appears to be wrong in his assertion that the auricle can have no influence in hearing, for it is well known that with the altered shape of the auricle in othæmatoma, the hearing is altered. He furthermore argues that the auricle in man is useless, because birds have none; but birds do not need an auricle, on account of the high resonance of their auditory canal, as well as the interference in flying such an appendage would entail. Dr. Küpper, therefore, places the auricle of man in the "list of organs inherited, but no longer possessed of functions." He, however, ascribes an important part to the auricle in the lower animals, agreeing with Müller[1] that as it is supplied with so many (17) well-developed muscles, it is well adapted to catch sounds, but especially to express the passions of the animal, as is best seen in the horse. Dr. Küpper, however, apparently does not believe that the auricle of man, while losing the function so sharply seen in the lower animals, gains a higher and more delicate one, of resonator for the nobler tones of the human voice, as shown by the author.

Prof. E. Mach[2] considers the auricles in the lower animals, resonators for the higher tones of ordinary sounds, important for them to hear, such as the rustling of grass and leaves. This function depends partly upon the ability of the animals to place the auricles towards the direction of the sound, and thus to alter the clang-tint, which leads to a proximate knowledge of the direction of the sound. A remnant of such a function may still be found in the human auricle, according to Mach, which agrees with the theories advanced, previous to those of Mach, by the author.[3]

In the summer of 1873, while I was travelling and exposed to a great variety of powerful sounds, of nature and of commerce, I made some experiments on my own external ears, respecting their power of receiving all or part of the component tones entering into such complex sounds, as the rustling of leaves, the roar of Niagara, the seething and hissing noise heard in the wake of a large steamer, or in the escape of steam from a powerful locomotive or steamboat. I found that by altering the position of my auricle, that is, by relatively lengthening

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[1] Physiologie der Haussäugethiere.
[2] Archiv f. Ohrenheilkunde, Bd. ix. p. 72, 19 June, 1874.
[3] Phila. Med. Times, No. 101, Oct. 4, 1873; No. 127, April 4, 1874.

thereby the depth of the external auditory canal, I could ana-
lyze the composite sounds alluded to, for if I pressed my auricle
firmly back against my head, I heard the higher sounds, *i. e.*
the entire sound became to my ear apparently of a higher
quality, whereas, if I pushed my auricle outward and forward,
the deeper partial sounds became more pronounced, and the
entire composite sound became louder and deeper. I joined my
friends, Drs. Buck and Blake, and communicated to them what
I had very easily found out, and as they are endowed with
musical or analytical ears, I requested them to repeat these ex-
periments upon themselves, which they did; Dr. Buck while
with me, and Dr. Blake subsequently after we parted, and they
both have confirmed my discovery.

In the autumn of 1873 I published my first paper, and in the
spring of 1874 my second paper on what I had observed re-
specting the function of the external ear, especially of the
auricle, viz., that it is a resonator for high notes.

The first paper contained chiefly a description of the pheno-
mena I had observed; and the second paper was devoted spe-
cially to their physical explanation.

The substance of the first paper was the following :—

Before any further explanation of the functions of the auri-
cle, let us briefly consider the acoustic nature of some of the
ordinary sounds which are received by it. It is well known
that every sound is composed of a collection of " partial tones"
or " over-tones" which determine its timbre or clang-tint. Any
one of the ordinary sounds of nature, as, for example, the roar
of a cataract or of the surf, and the rustling of the leaves in a
forest, is composed of a large number of partial tones, which,
for the sake of simplicity, let us call deep, intermediate, and
high partial tones.

The ordinary normal ear does not isolate any of the partial
tones of a composite sound, but perceives them as a whole.

This is due to the fact that certain parts of the auricle re-
sound best to the high partial tones, while other portions of it
resound best to the intermediate and low partial tones, thus
insuring the complete reception by the auditory nerve of all the
partial tones which compose any given sound falling on the
auricle. I have discovered, by experiments upon my own ear,
that the region of the helix and its fossa resound to the deeper

notes, the antihelix and its fossa to the intermediate notes, and
that the concha, "the deep concavity within the position of the
antihelix, presenting a semi-spiral course towards the entrance
of the auditory meatus," resounds best to the high partial tones.
In order to prove this it is necessary to be in the presence of a
sound possessing the characteristics of those already mentioned,
when, by pressing the auricle at its outer edge gently forward,
the sound instantly becomes a deeper one, from the augmenta-
tion of the resonance for deep tones thus gained by the helix
and its fossa.

The deep tones, however, are immediately weakened or lost
by placing the finger upon the helix and pressing it firmly
against the head. Then it is found that the sound becomes one in
which the intermediate and higher partial tones are prominent.
By pressure upon the antihelix the intermediate tones become
weaker, and the higher partial tones are most distinctly per-
ceived, on account of their undisturbed resonance in the concha.
Firm pressure upon the helix, antihelix, and concha will inter-
fere with the resonance of all but the highest partial tones. In
the latter instance the resonance of the meatus auditorius ex-
ternus has full scope, for this part of the ear, according to
Helmholtz, resounds best to notes of the fourth octave (e^{iv}–g^{iv}).
Therefore, if any one of these portions of the auricle has its
acoustic functions altered, either by disease or artificially, the
tones to which it resounds will be weakened or lost, and the
prominence of the other partial tones will change the timbre of
the original sound.

Experiment will show that by giving prominence to a certain
portion of the auricle, viz., the helix and its fossa, a sound may
be rendered fuller, and hence louder, from the increased reso-
nance of the deeper notes which enter into its composition.
This may explain the asserted increase of hearing in some cases
of othæmatoma, when the swelling may have rendered these
particular parts prominent, and thus have increased their reso-
nant power. But if the disease advance and produce great
swelling and rigidity of the auricle, as it usually does, we can
also readily understand the impairment of hearing in these
cases. One without an auricle, all the rest of the auditory ap-
paratus being normal, can indeed hear sounds, practically very
well, but they are altogether different, acoustically considered,

3

from the complete composite sound heard by the possessor of the normal auricle. In the former case, a large number of the partial tones being lost, the clang-tint of the sound is altered; whereas in the latter case, the auricle receiving and conveying synthetically all the partial tones to the auditory nerve, the timbre of the composite sound is fully perceived.

The substance of my second paper,[1] explaining what I had observed, was as follows:—

The auricle, in combination with the meatus auditorius, forms a resonator of a more or less conical shape, closed at the bottom by the membrana tympani, the special function of which is to strengthen by resonance those waves of sound which possess a short wave-length.

Let the accompanying diagram represent a section of the external ear, from the membrana tympani to the helix. The section is made from above downward, parallel to the long axis of the meatus auditorius externus, and gives an ideal representation of the manner in which the resonator we shall consider, is built up by the auditory canal and the successive columns or cups of air, represented by the concha and fossæ of the helix and antihelix.

Fig. 4.

DIAGRAM REPRESENTING THE TOPOGRA-PHICAL RELATION OF THE COMPONENT RESONANT CAVITIES OF THE EXTERNAL EAR.—a. Fossa of helix. b. Fossa of antihelix. c. Concha. m. Meatus auditorius externus. t. Membrana tympani.

The widest diameter of this resonant cone or funnel, or miniature "speaking-trumpet," i. e. the diameter obtained when the helix and lobe are made to approach each other about the opening of the external meatus as a common centre, does not exceed the wave-length of the note to which the resonator thus formed will respond. In order fully to understand how this resonant power is maintained by the external ear, and to sound-waves of what length it specially resounds, let us first consider the resonance of the meatus auditorius externus, and the physical reasons for such a function in it.

It is known that the external auditory meatus resounds to the

[1] Phila. Med. Times, April 4, 1874.

notes e^{iv} to g^{iv},[1] and that the column of air which most easily resounds to any given note is equal to one-fourth of the length of the wave of sound produced by that note.[2] Now, the wave-length is found by dividing the velocity of sound per second by the number of vibrations executed by the sounding body per second,[3] and the quarter of the result of this division, i. e. the quarter of the wave-length, will equal the length of the column of air which will act the part of a resonator for the note producing the sound-wave.

In order to appreciate this fact, let us work out a simple problem in physics, with the data before us, as follows: As already stated, the notes e^{iv} to g^{iv} have 2640 to 3168 vibrations per second, and the velocity of sound in atmosphere at 15° C. is equal to 1122 feet per second. Therefore, the length of the wave produced by the note of 3168 vibrations per second will be found by dividing 1122 by 3168. The answer will be, about three-eighths of a foot, or four and a half inches.

Now, the column of air which will resound to the note producing a wave of that length is equal to one-fourth of that wave-length, or one and one-eighth inch, which is just the short average length of the meatus auditorius externus. Some authorities give one and one-fourth inch as the average length of the meatus auditorius externus, but practically the normal human meatus has various lengths, passing gradually from the meatus proper into the concha. And this brings us to the second consideration connected with the phenomena of resonance manifested by the external ear, viz., that as the pitch of a note, let us say of e^{iv} or g^{iv}, falls, the wave-length must become greater, or, in other words, as the number of vibrations per second diminishes, the wave-length increases; which is but the enunciation of a common law of physics. It is now manifest that the column of air contained by the meatus auditorius externus will not be long enough to act as a resonator for waves of sound the quarter of which is represented by one and three-fourths to two inches.

Therefore, the concha is found superposed by nature upon the external auditory meatus, in order to lengthen it. We have already seen from experiments that the notes which resound to the

[1] Helmholtz's Tonempfindungen, p. 175, 1870.
[2] Tyndall, On Sound, p. 174, 1869.   [3] Ibid., p. 84.

column of air represented by the concha, *i. e.*, the concha in conjunction with the meatus auditorius externus, are lower than those which resound to the external auditory meatus when it is made to act alone, which can be accomplished by pushing the concha out of place by firm pressure of it against the head. The reason for this becomes very clear when we reflect that a note lower than those represented in the scale from c^{iv} to g^{iv} must have a greater wave-length, and therefore it requires a longer column of air as a resonator. If this lower note should fall in the octave below those notes already mentioned, the addition of the column of air in the concha to that in the meatus would supply the resonator.

If to this resonator, composed of meatus and concha, we add the fossæ of the antihelix and helix, we of course obtain longer or deeper resonating columns of air; and I know from my experiments that notes of still greater wave-lengths than those alluded to resound to the column of air represented by that contained in the fossæ of the auricle added to that of the concha and meatus auditorius externus.

By holding the hand behind or around the ear, we have the power of adding a still deeper column of air and its resonance to that of the external ear. Hence, the deaf person involuntarily places his hand to his ear, to increase, by resonance, the ordinary sound falling upon it. His hearing is thus strengthened, especially for those notes of high pitch and short wave-length to which the human voice owes its peculiar timbre or clang-tint. " It is indeed remarkable that the human voice should be so rich in over-tones (Obertöne), for which the human ear is so sensitive."[1] When the wave-length increases, as it does when the note becomes still lower than any of those alluded to, the resonance of the external ear ceases to exert any marked influence on the fundamental note. In such a case it is probable that the resonance of the room or street in which we are placed is aroused by the longer wave of sound ; but nature has supplied us, in the external ear, with an ever-present and delicate resonator for just those notes of short wave-length in which the human voice is so rich and to which it owes its special timbre.

We may, therefore, conclude that *the external ear (i. e.*, the

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[1] Helmholtz's Tonempfindungen, p. 176, 1870.

meatus auditorius externus and the auricle) *forms a resonator for those tones having wave-lengths the quarters of which are represented by the various depths of the column of air contained by the external ear.*

From what has just been shown respecting the resonant functions of parts and of the whole of the auricle and external auditory canal in man, it seems fair to suppose that the entire apparatus of the external ear in all animals is adapted to strengthening the sounds uttered by them and their species. The absence of a developed auricle in birds is not, in my opinion, an argument against its utility as a resonator in man, for the wave-lengths of the high notes which the former must both use and hear as a means of intercourse with each other, are so short that they will resound perfectly well in the shallow auditory meatus found in them.

Temperature of External Canal.—Dr. E. Mendel,[1] of the University of Berlin, has performed a series of experiments to find the relative differences between the temperature of the rectum and that of the external ear under physiological and pathological conditions of the general system.

In the normal condition, the temperature of the rectum is 0.02° C. higher than that of the external auditory canal.

Further experiments in cases of apoplectiform and epileptiform paralysis show that in such pathological states the temperature is higher than that in the rectum.

Sleep-producing doses of chloral do not materially alter the temperature of the rectum, but they reduce considerably the temperature of the external auditory canal. The amount of this depression in the ear varies from 0.04°–1° C. It sets in in from ten minutes to half an hour after the chloral is given, and lasts until sleep is ended.

Morphia has also a specific effect in reducing the temperature of the external auditory canal in varying amounts, from 0.1°– 0.45° C.

This I consider important for aurists to know, inasmuch as further experiments of Mendel[2] show that even ice-bags fail to reduce the temperature of the external auditory canal as chloral and morphia do.

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[1] Virchow's Archiv, 62 Band, 1874.   [2] Loc. cit., p. 141.

CHAPTER II.

THE AUDITORY CANAL.

ANATOMY.

The Temporal or Petrous Bone.—Before considering the anatomy and physiology of the external auditory canal, it will be necessary to examine into the development and anatomy of the temporal or petrous bone. The outer surface of the temporal bone represents the convex curve of a low arch, the spring line of which runs through the outer part of the middle lobe of the brain. The squamous portion, which is the larger part of this

Fig. 5.
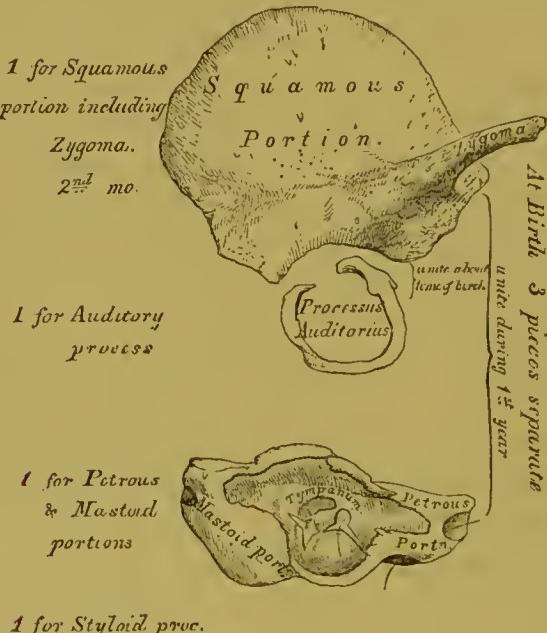
CENTRES OF DEVELOPMENT OF THE TEMPORAL BONE. (Gray.)

surface, being thin, and the arch it spans low, the temporal bone would be very weak in resisting external forces, were it not for the support placed on its inner surface by the petrous portion.

The temporal bone develops from four distinct centres, exclu-

sive of those representing the internal ear and the auditory ossicles.

These are: one for the squamous portion and the zygoma; one for the auditory process, or annulus tympanicus, which finally becomes the tympanic bone, and forms the anterior, inferior, and superior part of the osseous auditory canal; another for the petrous and mastoid portions, and a separate point of development for the styloid process.

It appears, from the anatomical investigations of Prof. Politzer,[1] that the styloid process, the variable form of which is well known, originates from an individual cartilage-centre, which, not only in foetal life but also in the new-born child, is
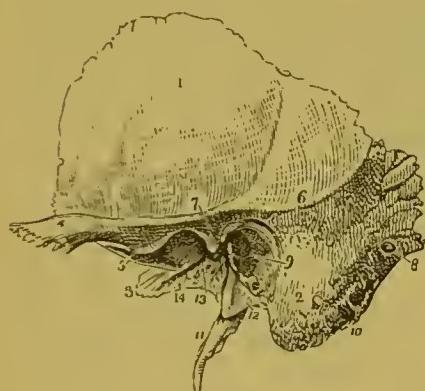
Fig. 6. Fig. 7.
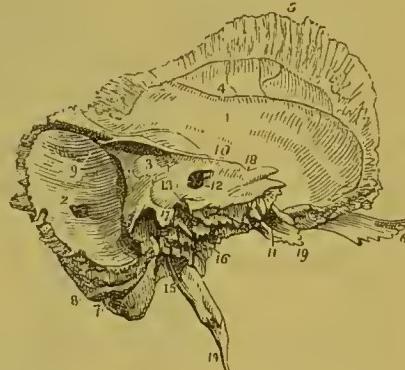
Fig. 6. OUTER SURFACE OF LEFT TEMPORAL BONE. (Smith and Horner.)—1. Squamous portion. 2. Mastoid portion. 3. Extremity of petrous portion. 4. Zygomatic portion. 5. Tubercle on which the condyle of the lower jaw touches, when the mouth is widely opened. 6. Posterior part of the temporal ridge. 7. Glenoid fissure. 8. Mastoid foramen. 9. External auditory meatus surrounded by the auditory process. 10. Fossa for digastric muscle. 11. Styloid process. 12. Vaginal process. 13. Glenoid foramen. 14. Part of the Eustachian groove.

Fig. 7. INNER SURFACE OF THE LEFT TEMPORAL BONE. (Smith and Horner.)—1. Squamous portion. 2. Mastoid portion. 3. Petrous portion. 4. Groove for the posterior branch of the middle artery of the dura mater (meningea media). 5. Bevelled edge of the squamous portion. 6. Zygomatic process. 7. Digastric fossa. 8. Occipital groove. 9. Groove for the lateral sinus. 10. Position of the superior petrous sinus. 11. Opening of the carotid canal. 12. Meatus auditorius internus. 13. Aquaeductus vestibuli. 14. Styloid process. 15. Stylo-mastoid foramen. 16. Carotid foramen. 17. Spine separating the eighth pair of nerves from the jugular vein. The dark spot in front of the number 17 is the position of the opening of the aqueduct of the cochlea. 18. Points to the Vidian foramen on the anterior surface of the petrous portion. 19. Origin of the levator veli palatini, and of the tensor tympani muscles.

demonstrable as a separate cartilaginous body, and that the upper end of the styloid process is not found at the externally visible base of the process, but that it extends upward as far as

[1] Archiv f. Ohrenh., Bd. ix. p. 164.

the lower part of the eminentia stapedii, along the posterior
limit of the tympanic cavity, from which it is separated by a
thin osseous lamella.

Space forbids a lengthy consideration of the developed tempo-
ral bone, but a few prominent features deserve notice here, as,
that under the floor of the tympanic cavity is part of the jugu-
lar fossa; that the anterior wall is part of the carotid canal;
that the roof of the tympanic cavity is a thin bony septum be-
tween the brain and the middle ear; and that the mastoid cells
are separated by a thin partition of bone, from the sigmoid
fossa, in which runs the lateral or transverse sinus of the dura
mater.   In addition to these facts may be mentioned that the
entire internal ear, or labyrinth, lies in the petrous pyramid of
the temporal bone, that the middle ear is formed by the union
of the squamous, petrous, and mastoid portions of the temporal
bone, and that the osseous portion of the Eustachian tube lies in
the inner end of the petrous portion of the temporal bone, through
which the tensor tympani muscle may be said to run on its way
to the tympanum.   Its more detailed arrangement will be ex-
plained when alluding to the soft parts of the Eustachian tube.
Furthermore, the levator palati, an important tubal muscle,
originates at the under surface of the temporal bone, near the
inner end of the petrous part; the carotid canal passes through
this part of the bone, and the jugular fossa is partly formed by
the temporal bone; the facial nerve passes through this bone
from the brain to the face, and the aquæductus cochleæ, the im-
portant exit for the perilymph of the labyrinth, is placed near
the carotid canal on the under surface of the temporal bone.
It is also important for the aurist to bear in mind that on the
upper and cerebral surface of the petrous portion are the petro-
sal sinuses, and that these are closely connected with the cavern-
ous sinus, which in turn is emptied into by the ophthalmic
vein, a relationship which may often explain facial and ocular
symptoms in obstruction of the sinuses from aural disease.

The small opening of the aquæductus vestibuli, on the pos-
terior surface of the pyramidal petrous part of the temporal
bone, near the entrance of the auditory nerve, must not be for-
gotten, as at this point purulent disease may often be found to
have entered the cranial cavity from the tympanum and vestibule.

The anterior wall of the bony auditory canal forms part of

the glenoid fossa, and it can thus be seen how, in certain inflammations about the ear, movements of the jaw are exceedingly painful.

Fig. 8.
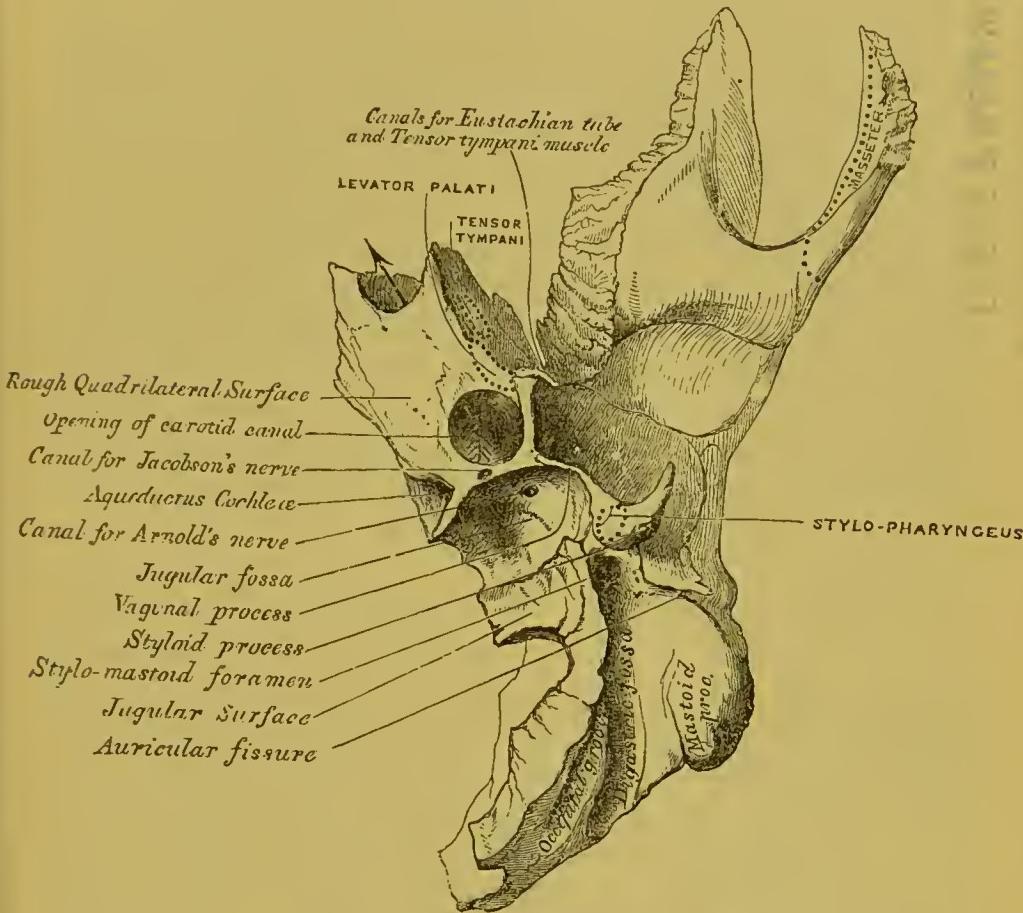
UNDER SURFACE OF LEFT TEMPORAL BONE. (Gray.)

At birth the bony auditory canal does not exist; the ring from which it is developed is deficient at the upper fourth, and the canal is represented at that point by the curved lower edge of the squama. The aforesaid ring grows at last into a tube which forms the posterior, inferior, and anterior wall of the osseous external auditory canal, to which the name of tympanic bone is also given. In the new born child the mastoid portion is also rudimentary and not fully united with the squama. At the line of imperfect union between these two parts of the temporal bone, quite large deficiencies are found in early childhood and in some cases persist even into adult life.

Development of the Bony Auditory Canal.—The osseous auditory canal, *i. e.* the inner and major portion of the entire auditory passage, is developed from the so-called drum ring, *annulus tympanicus* or *processus auditorius*. This ring, which is open or interrupted (for 1–2 mm.) at a point in its postero-superior periphery, has a furrow on its inner edge called the sulcus tympanicus. This ring, united to the squamous and petrous portions of the temporal bone, gradually grows outward, and forms the antero-superior, anterior and antero-inferior wall of the bony auditory canal.

The two prominent points (see Fig. 5) on the anterior and upper part of the ring are called by Henlé *spina tympanica antica* and *postica*, and are the terminal points of a ridge forming the upper boundary of a furrow called the *sulcus malleolaris*, which finally becomes the posterior boundary of the *petrotympanic fissure* for the reception of the long process, processus folianus of the malleus, and the various soft parts which pass through the aforesaid fissure, also called the Glaserian fissure.

Development of the Annulus Tympanicus.—The spina tympanica antica unites with the tegmen tympani and thus completes the petrotympanic fissure posteriorly, but the spina tympanica postica projects beyond or behind the tympanic margin of the squamous portion of the temporal bone, and also behind and above the drum-head, and inserts itself at last into the depression between the head and the handle of the mallet, called the neck, as shown by Henlé. Considered as anatomical points these are quite insignificant, but when taken in their physiological relations with the support they give to the malleus they are of great importance. As the bone develops the *spina tympanica antica* grows away, as it were, from the *spina tympanica postica*, and is finally seen at a point far down on the superior wall of the bony portion of the canal, in the fully developed broad tympanic bone. As, however, the spina tympanica postica of Henlé, in the fœtal bone, becomes of so much importance as the anterior point of insertion for the ligaments supporting the malleus in the developed organ, Helmholtz has given to it, in its physiological relations, the name *spina tympanica major ;* and to a less prominent point on the postero-superior portion of the ring in which the drum-head is inserted, he gives the name of

spina tympanica minor. The latter forms the posterior point of insertion for the suspensory ligaments of the malleus. The neck of the malleus fits in between these two points in such a manner that the anterior almost touches it. In the perfect bone this relation is not visible from without.

The line of attachment of the membrana tympani also shows a slight and ill-defined depression where it passes near and beneath these points, *i. e.*, at its upper periphery above the short process of the hammer. Here the line of insertion of the drum-head is less sharply defined than it is lower down the periphery. At this ill-defined point in the upper part of the periphery of the membrana tympani, "slight pressure with a blunt instrument will loosen the membrane from its attachments. In fact it is more truly attached to the cutis than to the bone."[1]

Segment of Rivinus.—This segment in the upper border of the drum-head is called the segment of Rivinus, since it includes the foramen described by Rivinus, an opening which in some instances represents the last trace of the first visceral cleft, but which really has no existence in the majority of normally developed adults.

The Auditory Canal.—The external auditory canal extends from the bottom of the concha to the drum-head, and consists of a cartilaginous and a bony portion, the former being about one-third and the latter about two-thirds of the passage.

The length of the auditory canal is about one inch and a quarter, and its average width is about a quarter of an inch.[2] The canal gradually narrows to the middle of the bony portion, where it widens again gradually to the drum-head. A horizontal section, therefore, of this canal will be proximately represented by that of two detruncated cones placed together at their points of detruncation. The auditory canal is lined with skin, a continuation of that of the auricle, and *not* with mucous membrane. The skin of the canal is extended over the drum-head, forming its dermoid or outer layer, so that a glove-finger

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[1] Mechanism of the Ossicles of the Ear and the Membrana Tympani. H. Helmholtz, Bonn, 1869. English translation by A. H. Buck and Normand Smith, New York, 1873.

[2] Richet, eight to nine mm. at the opening, and from six to seven mm. at the fundus of the canal. (Hyrtl.)

will represent very well the shape of the cutaneous lining of the canal, the finger-tip being the position of the drum-head. In the bony portion of the canal, the skin is thin and closely adherent, its silvery lustre having probably led earlier observers

Fig. 9.
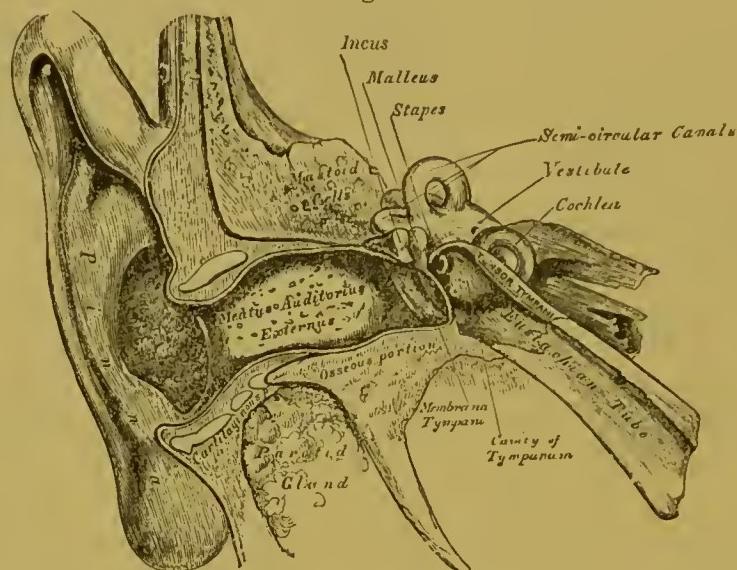
TRANSVERSE SECTION OF THE ENTIRE AUDITORY APPARATUS OF THE RIGHT SIDE. (Gray.)

to call it a mucous membrane; but there is no such membrane in the external ear. In the inferior wall of the meatus there are deficiencies in the cartilage called the *incisuræ Santorini*, and there is a cleft in the upper wall of the cartilaginous part of the canal. The general course of the external auditory canal may be described as sigmoid, or as a spiral turning anteriorly inward and downward, though there are many individuals in whom the auditory canal is so straight that their drum-heads may be seen very easily by direct inspection and without dilation of the cartilaginous part of the passage. I have frequently inspected the drum-head in such cases without the knowledge of the person examined, sometimes while riding in a street car. Such straight canals are invariably wide ones; and much more common in the black than in the white race.

Although the external auditory canal is usually spoken of as tortuous, I have observed that in the negro it is usually wide and straight, so much so, in fact, that in most cases, in this race, I have been able to see the membrana tympani without

the aid of speculum and reflected light, being able to look directly down upon the drum-head. I have sometimes, though very rarely, seen the same kind of a wide and straight auditory canal in the white man.

Could the large auricle and auditory canal have any connection with the musical talent universally found in the negro race in this country? In the white race, the wide and straight meatus, according to my observation, is found in individuals more than ordinarily endowed with the so-called musical ear.

Upon the entire free surface of the cutis of this canal are found epidermis and soft short hairs, together with the sebaceous glands usually found in connection with them. Throughout the canal, especially in the bony portion, are found vascular papillæ arranged in parallel rows, and glandular structures closely resembling sudoriferous glands, but which in their modified form are called ceruminous glands.

Ceruminous Glands.—These glands begin about two mm. from the opening of the auditory canal, and extend to within two to three mm. of the drum-head; they are found in the bony as well as in the cartilaginous part of the canal. They are most numerous at the junction of the cartilaginous with the bony canal, where they average as many as ten to the square millimetre. According to Buchanan, there are from one thousand to two thousand in an auditory canal. The thickness of the skin in the cartilaginous part of the auditory canal is one and a half mm. thick.

Vessels and Nerves.—The arteries supplying the auditory canal are branches from the posterior auricular, internal maxillary, and temporal. The nerves are chiefly derived from the temporo-auricular branch of the inferior maxillary nerve. There is also an *auricular branch* of the pneumogastric nerve.

PHYSIOLOGY.

The acoustic physiology of the external auditory canal has been alluded to in speaking of the functions of the external ear as a resonator. There is one function it possesses, that of causing the ear-wax and some small foreign bodies to fall out from it, which is not fully explained.

Voltolini[1] has shown, that if a foreign body is wedged in a swollen auditory meatus, and the former be made smaller by any means, but especially by the galvano-caustic, the body thus reduced will be pressed out by the swollen walls of the auditory canal. This he claims to be an invariable physical process. Perhaps we may explain the natural escape of cerumen from the ear in some such way as the following: The ear-wax is mostly formed in the wide end of a detruncated cone, i. e., near the outer end of the auditory canal. Therefore, as the wax forms, it presses upon the walls of the auditory canal, and the latter being widest towards the mouth, i. e., freest on the outer side of the gradually growing mass of cerumen, the latter meets with the least obstruction just in the direction of its only escape; hence it will be acted upon very much as if it remained a constant quantity, which is being continually pressed upon from behind, and pushed outward by a gradually narrowing auditory canal; for, as the mass accretes, it must necessarily, with its naturally lubricated surface, slip into a broader, which is an outer, plane in the external auditory meatus, and thus at last it may be found at the mouth of the auditory canal. Unfortunately, this delicate function is constantly interfered with by those who, in endeavoring to clean out wax, push in more than they bring out, and thus, in a short time, form obstructive plugs of cerumen.

Another mode by which cerumen is aided to fall out of the auditory canal, if let alone, has been suggested to me by watching the gradual outward movement of a scab on the membrana tympani, and of a similar object on the wall of the auditory canal. If a little fleck of blood forming on the membrana tympani, or on the wall of the external auditory canal, be watched for some days, it will be observed to change its position by moving outward, strongly suggestive of the manner in which a spot over the matrix of the finger nail will gradually grow to the edge of the nail and disappear. I have watched little scabs of blood thus move from the drum membrane to the wall of the canal, and from the inner part of the latter similar substances may be seen to move outward to the mouth of the meatus. In some such way, I believe the outward growth of the skin of the auditory canal helps to force out the superabundant ear-wax.

[1] Monatsschr. f. Ohrenh., No. 9, 1872, and elsewhere.

CHAPTER III.

MEMBRANA TYMPANI.

ANATOMY.

THE membrana tympani, or drum-head, is composed of three layers, viz.: the external or dermoid layer; the middle or fibrous layer, also called the membrana propria; and the internal or mucous layer.

The Dermoid Layer.—The dermoid layer of the membrana tympani is a continuation of the cutis of the external auditory canal. This may be seen if the skin of the canal be macerated properly, when the entire cutaneous lining may be removed in the shape of a glove-finger, the tip of which will represent the dermoid layer of the drum-head. In this layer there are, however, no hairs nor follicles such as are found elsewhere in the cutis of the auditory canal. In other respects, it is true skin, but extremely thin and transparent.

The Outer Surface of the Membrana Tympani.—The dermoid layer is the only one of three layers composing the membrana tympani, which can be inspected directly from without. When the ear is illuminated and a normal membrana tympani examined from without, there are several prominent features in it, which at once attract attention, viz.: its almost circular shape and peculiar polish and color; its vertical and horizontal inclination; the manubrium of the malleus; the short process of the latter; the folds of the membrana tympani; the flaccid portion of the drum head above these folds, called the membrana flaccida or

Fig. 10.
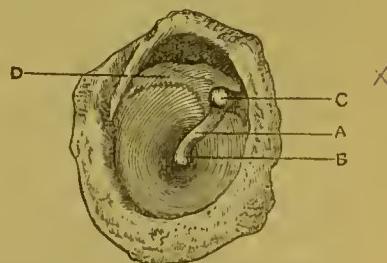
VIEW OF OUTER SURFACE OF MEM-
BRANA TYMPANI. (Gruber.) — A.
Malleus; manubrium. B. Short pro-
cess; C. The tip of the manubrium.
D. Posterior fold.

Shrapnell's membrane; and the bright triangular reflection of light in its antero-inferior quadrant, called the "pyramid of light."

Shape of the Membrana Tympani.—For purposes of convenience in description, the outline represented by the periphery of the membrana tympani is called circular. This form, however, varies between that of an ellipse and an irregular oval, while in some cases where the lateral portions of the annulus tympanicus are especially curved outward, it assumes a heart shape.

It may be strictly considered an ellipse, the long diameter of which, amounting to 9–10 mm., runs from above and in front, downward and backward, and the diameter of greatest width of which runs from below and in front, upward and backward. These measurements are those given by v. Trœltsch, and are nearly in accordance with those of Hyrtl, according to whom the proportion between the diameters is as 4.3‴–4.0‴.

Since the difference between them is so slight, and their inclinations are so nearly vertical and horizontal, the outline of the membrana tympani may be considered circular, and the long diameter is spoken of as the vertical diameter, while the diameter of greatest width is considered the horizontal diameter.

The membrana tympani is therefore divided into quadrants, which greatly aid in locating any point to be described.

Color of Membrana Tympani.—The normal color of the membrana tympani is never fixed. Just as some normal teeth are bluish or yellowish-white, so it is with the drum-head, which though perfectly normal may be bluish or yellowish-gray, though more frequently it is found to be the former. The normal color of the drum-head is usually spoken and written of as " pearl gray," but whatever color the membrana tympani may be said to have, that color *must always be modified by* the physical conditions brought about by stretching a slightly transparent membrane over a darkened cavity. And this is a modification not sufficiently taken into account by observers. There is therefore, from the cause just mentioned, an admixture of black with the delicate gray of the membrane, but it is very difficult to *paint* a *transparent* or translucent object, and therefore very difficult to ascribe even a name to the color of a normal membrana

tympani, since its appearance is partly due to the color which
its own substance reflects and partly to the color it transmits
from the cavity of the drum, the latter feature of course being
modified in every imaginable degree by the thickness or thin-
ness of the membrana tympani, as well as by the various condi-
tions and colors of the contents and lining of the tympanic
cavity.

Modifications of color similar to those in the membrana tym-
pani can be in a measure produced artificially, if we stretch a
piece of gold-beater's skin, delicate tissue paper, or sheet gutta
percha over a rather shallow cavity rendered dark by covering
it in this manner.

The color of the membrane thus formed will be composed of
the latter's own peculiar tint as an opaque substance and the
color of the cavity over which it is stretched and which it
transmits.

Just such conditions of coloring due to the fact that the
membrana tympani is a slightly opaque substance and to the fact
that it transmits color from the tympanic cavity must be borne
in mind, in any attempt at naming its color, which therefore
will ever be composed of the tint of the membrane modified by
the color it transmits.

Prof. Politzer defines the color of the normal membrana tym-
pani, as " a neutral gray tint, with an admixture of violet and
light brown."

" That part of the membrana tympani, just behind the lower
end of the manubrium, and over the promontory of the cochlea,
is rendered yellowish-gray by the rays of light reflected from
the yellow bone of the inner wall of the tympanic cavity."   Of
course all these shades of color vary a little, even in the normal
state ; but greatly during pathological processes in any part of
the structures entering into the formation of the drum-head.

The membrana tympani owes its peculiar lustre to the delicate
and shining epithelium of the dermoid layer.

If a fresh membrana tympani be placed in a solution of nitrate
of silver, the peculiar cement-like substance between the scales
of this epithelium will become tinged, while the scales them-
selves will remain uncolored, and thus a distinctly marked pre-
paration will be made in which the various shapes of the epithe-
lial scales become demonstrable under the microscope.

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The slightest maceration or exfoliation of this delicate epithelium deprives the membrana tympani of its beautiful gloss.

The dermis of the drum-head is thickest in children.

The Inclinations of the Membrana Tympani.—Another important feature which attracts the attention of one examining the ear is, that the membrana tympani, in its normal condition, is inclined at an angle of 45° in its vertical plane, and in its horizontal plane is inclined 10° towards the right on the right side and 10° towards the left on the left side.

If the planes of both membranæ be extended downward until they intersect each other, the angle which they will thus form will be equal to about 130°–135°.

Of still greater importance than this, however, is the direction of the walls of the auditory canal from the plane of the membrana tympani.

Thus if a perpendicular be drawn from the upper pole of the drum-head to the inferior wall of the auditory canal, it will strike the latter about 6 mm. from the inferior pole of the membrane.

A similar result will be obtained by drawing a perpendicular from the middle of the posterior periphery of the drum-head to the anterior wall of the auditory canal, from which fact it becomes very evident that the antero-inferior part of the membana tympani is further removed from the external opening of the auditory canal than the postero-superior part.[1]

The membrana tympani is inclined the most in very young children, being in the early years of life, almost horizontal in position, and, on account of the shallowness of the auditory canal at that time, the membrane is very superficial, especially at its upper part.

The Manubrium of the Malleus.—Running from above downward and backward, to the centre of the membrana tympani is seen the ridge formed by the manubrium of the malleus.

This slightly elevated ridge, entirely opaque and decidedly whiter than the surrounding drum-head, divides the membrana tympani into two unequal parts, the anterior being the smaller and

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[1] Gruber, Studien uber das Trommelfell, p. 4.

the posterior the larger. At the upper end of this ridge is the
short process of the malleus, projecting sharply outward, somewhat
above the general surface of the handle of the hammer. In gene-
ral appearance it is not unlike a pimple with yellowish contents.

The lower end or tip of the ridge, which curves slightly for-
ward, is flatter, broader, and yellower than the rest of the outer
covering of the manubrium. This is due to the fact that the
bone proper is spade-shaped at this point, and also because the
radial fibres of the membrana propria centre at this lower part
of the bone.

The lower end of the manubrium draws the membrana tym-
pani inward very markedly, and forms that depressed spot in
the centre called *the umbo.*

The convex shape of the drum-head from the tip of the manu-
brium outward towards the periphery is due to the compara-
tively large number of circular fibres at a point between the
umbo and periphery, which constrict, as it were, the radial
fibres, so as to form a kind of funnel.
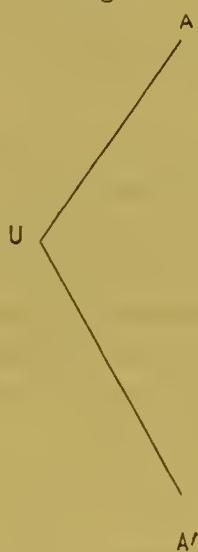
Fig. 11.   Fig. 12.

Pressure or traction applied to the centre of a membrane
stretched over a ring, tends to draw the former into a cone, a
vertical section of which is represented by the line A U A′ in
Fig. 11.

But if a smaller concentric ring be placed at B C so as to resist
the indrawing force at U, the curve assumed by the membrane

is represented by the line A U A' in Fig. 12, and the whole membrane is drawn into a concavo-convex shape.

The Yellow Spot at the End of the Manubrium of the Malleus.—
This spot is not a pathological appearance, but a purely physiological condition. It is part of the cartilaginous structure at the end of the hammer.

Dr. Trautmann,[1] who has made a special study of the spot, concludes that its physiological significance is the same as an epiphysis of a long bone.

The diagnostic value of the yellow spot is considered by him to be apparent in cases of thickening of the membrana tympani, when the former will disappear much sooner than the sharp edge of malleus. 2. Opacities of the membrane with thickening change the color of the yellow spot. 3. When the malleus is twisted on its long axis the form of the spot will be altered. 4. If the spot does not move during alterations in the atmospheric pressure in the canal, by means of Sigle's speculum, it is fair to conclude that either anchylosis of the malleus or its adhesion to the inner wall of the tympanic cavity has occurred. In the latter instance the differential diagnosis is aided by the necessary foreshortening of the handle of the hammer.

Folds of the Membrana Tympani.—From the short process of the manubrium of the malleus two delicate ridges may be seen, one passing forward, the other backward to the periphery. These are the so-called folds of the membrana tympani. They are formed by the pressure from behind, produced by the short process of the malleus. They are important topographical as well as diagnostic points of the membrana tympani. Above these folds is the so-called membrane of Shrapnell,[2] or membrana flaccida. It owes its flaccidity to the small amount of fibrous tissue entering into its composition, and to the loosely stretched cutaneous and mucous layers of the membrana tympani, which here come together. In this membrane somewhere, there is

[1] Archiv. f. O. B. xi. p. 99–113.
[2] Henry Jones Shrapnell, not Odo Shrapnell, as several German authors have called him. This author's description of the membrana flaccida is found in London Med. Gazette, vol. x. p. 120.

said to be a normal opening, the foramen of Rivinus, named after the writer, who first called attention to its supposed existence in 1717. Ever since, the dispute has turned upon several points, viz., first, whether there is such an opening; secondly, is it normal or pathological; and lastly, in what part of the membrane is it found.

Although a number of distinguished observers, among whom may be quoted Patruban, Gruber, Politzer, and Hyrtl, have investigated this point in the anatomy of the membrana tympani, the question was for a long time an open one, until Hyrtl denied the existence of a normal opening in the membrana flaccida, either in the adult or in the infant cadaver. He, however, admits that a *want of development in the membrane* in the neighborhood of the Rivinian segment may, in some cases, lead to the formation of a quasi foramen, but the normal existence of such a foramen is not proven. Such testimony as Hyrtl's is incontrovertible in the author's opinion, and can never be overthrown by the assertion that the opening is so small, that the anatomist must look for hours with a magnifying glass, in order to find it; nor can I understand how a foramen should be so small as to require such persistent search with a magnifying glass, and yet, when found, be large enough to allow a bristle to pass in and through it. I have surely never seen any opening in this part or any other part of the membrana tympani that was not purely pathological. The occurrence of any opening in the membrana flaccida is most rationally accounted for by Hyrtl's explanation, viz., by a want of normal development, or by a pathological loosening of the fibres of the flaccid membrane from their very loose connection with the horizontal edge of the squamous portion of the temporal bone, at that point known as the Rivinian segment of the periphery of the membrana tympani.

Pyramid of Light.—The pyramid of light is a name applied to the beautiful triangular reflection of light emanating from the antero-inferior quadrant of the normal membrana tympani. The apex of this triangular reflection touches the tip of the manubrium of the malleus, and its base lies on the periphery of the membrana tympani. It forms with the handle of the malleus an obtuse angle anteriorly, which becomes greater as the

inclination of the membrana tympani to the auditory canal diminishes. Its average height is from 1½ to 2 mm., and its average width at the base is from 1½ to 2 mm. This reflection, which has been called an isosceles triangle from its general appearance, is strictly considered pyramidal in shape, and hence the name applied to it by most writers of the present day. Wilde, of Dublin, called it the "speck of light," and many of the Germans call it the "reflection of light."

The causes of the formation of this pyramid of light, or, in other words, the optics of this important spot, have been variously explained by a number of careful observers. Wilde, the first to describe it, believed it to be due to the convexity of the membrane, but other observers since that time, among whom may be named Politzer,[1] Gruber,[2] Voltolini,[3] and Trautmann,[4] have most clearly shown that such a convexity is not the only cause of the formation of the pyramid of light. From the more recent investigations, it is most conclusively proven that there are three elements indispensable to the formation of this peculiar reflection of light, viz., a shining surface, the inclination of the membrane, and its peculiar funnel-like shape. In these three conditions may be found the solution of three very important questions, viz.: 1. Why do we see such or any reflection from the membrana tympani? 2. Why do we see this one in the antero-inferior quadrant? And, 3. Why is its shape pyramidal?

The *first* condition, viz., the reflecting surface, is supplied by the lustrous epithelium of the dermoid layer of the membrana tympani, and thus an answer is given to the first question.

The *second* condition, viz., the peculiar inclination of the membrana tympani, so places the membrane that, by the modifications of its surface brought about by the traction inward at the umbo, the only possible spot from which light can be reflected is just where the pyramid of light is seen. This point will be more fully explained further on.

The *third* condition, viz., the funnel shape of the membrana

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[1] Die Beleuchtungsbilder des Trommelfells im kranken, und gesunden Zustande, Wien, 1865.

[2] Anatomisch. Physiologische Studien, uber das Trommelfell und die Gehörknochelchen, Wien, 1867.

[3] Monatsschr. f. Ohrenh. Jahrg. vi., No. 8.

[4] Archiv f. Ohrenheilkunde, Band ii., N. F., 1873.

tympani, will explain the pyramidal shape of this reflection, upon the physical law pertaining to concavo-convex mirrors.

Not one of these conditions is sufficient of itself to produce a normal pyramid of light on the drum-head. That the lustre of the dermoid layer is an important factor in producing this peculiar reflection, may be easily proven by syringing an ear in which the pyramid of light is seen in its normal condition. After a slight maceration of the dermoid layer has been thus produced, and its shining surface destroyed, the pyramid of light will be found to have disappeared or to have become dulled or distorted.

In order to prove that the peculiar inclinations of the membrana tympani, respecting the walls of the auditory canal, have also their part in the formation of the pyramid of light at that point where it is normally found, viz., in the antero-inferior quadrant, it is only necessary to inspect a normal drum-head in which the reflection of light, in question, is found, during the inflation of the tympanic cavity by the Valsalvan or any other method.

It will then be seen that the pyramid of light becomes altered in its *position in respect to the malleus.* That this reflection can come only from the antero-inferior quadrant, is further shown by an experiment of Politzer's, as follows :—

If the auditory canal be removed from the membrana tympani, so that the latter is attached only to the annulus tympanicus, and the membrane then be revolved, so that other parts of its surface successively assume the position of that from which the pyramidal reflection formerly came, we shall perceive on each of these parts a reflection almost exactly like the original pyramid of light, excepting behind the manubrium, where, owing to the different curve of the membrane, the reflection in question will be somewhat different, both in shape and brilliancy.

The third important condition in the formation of the pyramid of light, is the funnel shape of the membrana tympani, to which is due, according to Trautmann, the pyramidal shape of the reflection under consideration.

The Cause of the Pyramidal Shape.—It is already known that the membrana tympani is drawn inward in such a way by the

manubrium of the malleus and the peculiar distribution of fibres in the membrana propria, that its general shape may be likened to that of a shallow funnel or the flower known as the "morning-glory" or convolvulus.[1]

As its surface is very polished, it may be considered a convex mirror, which, for the sake of better explaining the pyramidal shape of the light spot of the membrana tympani, we may consider a convex mirror composed of an indefinite number of sections of convex mirrors with radii varying from that of a mere point to that of the circle which the periphery forms. Now, since it is a law of physics that the image reflected from convex mirrors varies in size directly as the radius of the mirror, we shall have in the composite convex mirror represented by the drum-head, an image, which at the centre, i. e., at the point of the manubrium, is a mere point of light, but which gradually enlarges towards the periphery, until we perceive a triangular spot with its base on the periphery, the height of which depends on the distance of the centre of the mirror from the periphery, and the breadth of the base of which depends on the dimensions of the periphery ; the greater the latter the wider the base of the triangle of light.

Dr. Trautmann thus sums up the causes of the pyramid of light: "The normal membrana tympani has quite a high degree of superficial lustre, is inclined at an angle of 45° in its vertical plane, and in its horizontal plane it is inclined 10° towards the right on the right side, and 10° towards the left on the left side. Furthermore, it is drawn inward so as to form a funnel, the point or apex of which lies in the centre of the anterior periphery of the yellow, sickle-shaped expansion at the end of the anterior edge of the manubrium of the malleus, the angle at which the walls of the funnel meet is greater than a right angle, the depth of the funnel is equal to about 2 mm., and the distance from the apex to the periphery is 2½–3 mm. anteriorly, and 3 mm. posteriorly.

"Therefore, a 'spot of light' or a reflection of light from the plane surfaces of the membrana tympani cannot reach the eye of an observer, because the rays of light from without, on ac-

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[1] Voltolini, loc. cit.

count of the inclination of the membrana tympani, fall upon the plane surfaces of the same, at a very acute angle, and since the angle of reflection is equal to the angle of incidence, the rays of light reflected from the planes of the membrane which has an inclination of 45°, must strike the inferior wall of the external auditory meatus, and are in consequence unable to reach the eye of the observer.

"The relations are, however, different, when we consider the 'reflection of light' which is found in the funnel-shaped tract. On account of the vertical inclination of 45° of the membrana tympani and of its horizontal inclination of 10°, the antero-inferior quadrant of the membrana tympani is at right angles to the illuminating object. Since, now, the illuminating body and the eye are in the same line, or should be, in order to obtain the best possible illumination of the membrana tympani, only the rays of light which fall perpendicularly upon the antero-inferior quadrant can reach the eye, since all other rays are reflected at such an angle that they strike the walls of the auditory canal; therefore, the only reflection of light seen by the observer comes from the antero-inferior quadrant of the membrana tympani."[1]

Geometric Divisions of the Membrana Tympani.—Kessel[2] has divided the membrana tympani into two grand divisions, one above, the other below the folds of the drum-head, *a e, e d.* The upper division is subdivided into three sectors, viz., *a e b, b e c,* and *c e d,* Fig. 13. The *sectors* are bounded below by the folds of the membrana tympani and above by the annulus tympanicus and the segment of Rivinus, *b c.* The middle sector *b e c,* is separated from the other two on each side by the two suspensory ligaments *b e, e c,* of the

Fig. 13.

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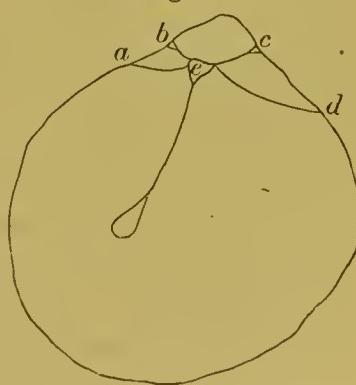
[1] Loc. cit., p. 28.

[2] Ueber den Einfluss der Binnenmuskeln der Pankenhöhle auf die Bewegungen und Schwingungen des Trommelfells am todten Ohre. Archiv f. Ohrenheilk. N. F., Band 2, 1874.

handle of the hammer. Between the anterior suspensory liga-
ment, *bc*, and the anterior fold of the membrana tympani lies the
anterior sector, and between the posterior suspensory ligament
and the posterior fold of the membrana tympani lies the poste-
rior segment. The inferior division of the membrana tympani,
viz., that portion below the *folds*, is divided into an anterior
segment beginning at the anterior fold of the membrana tympani
and extending to the pyramid of light, and the posterior seg-
ment extends from the pyramid of light to the posterior fold of
the membrane.

Dr. Kessel says: "Making the pyramid of light the inferior
boundary between these segments is not arbitrary, but has a
good reason in the fact that the radial fibres, running downward
and forward, *i. e.*, in the tract of the triangle of light, from the
point of the manubrium of the malleus, in a drum-head of nor-
mal position are shorter and therefore tenser and more retracted
than those fibres which run directly backward and forward from
the manubrium."

Annulus Tendinosus.—Before considering the membrana pro-
pria, the structure from which the fibres of this middle layer of
the membrana tympani arise demands a short description. This
is the so-called annulus tendinosus,[1] or tendinous ring of Arnold.
It is a mass of fibrous tissue arranged around the periphery of
the membrana tympani, effecting the union between the latter
and the inner edge of the external auditory canal.

The *annulus tendinosus* is not found, however, at that part of
the periphery of the membrana tympani corresponding to the
Rivinian segment, nor is it always visible from without, even
when present in its normal position, around the periphery close
to the annulus tympanicus.

The fibres of the membrana propria, the origin of which has
just been explained, are not inserted directly into the bone of
the manubrium, but into a cartilaginous groove which receives
the manubrium and short process. This peculiar structure was
discovered and has been fully described by Gruber.[2]

It presents in general the appearance of a deep groove, when

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[1] The annulus cartilagineus of the older writers.
[2] Studien über das Trommelfell, u. s. w., pp. 20–27.

seen from behind after the removal of the malleus. As shown
by Gruber, this groove is closed at its upper end so that it forms
a cartilaginous cap, which covers in the short process on all sides;
its lower end, on the contrary, is open behind, and it gradually
becomes shallower, *i.e.*, flatter, until it is at last lost in the sub-
stance of the membrana tympani. It extends from a little above
the short process to a point ½ mm. below the spade-like end of
the manubrium.

Inner Surface of the Cartilaginous Groove.—The inner surface of
this cartilaginous groove, which is in contact with the malleus,
is lined by a very delicate layer of connective tissue, between
which and the malleus there is found a small amount of fluid
resembling synovia. As this condition of discontinuity be-
tween the malleus and the inner surface of the cartilaginous
groove is considered normal by Gruber, it is fair to presume
that, such being the case, the malleus can make a certain amount
of motion in this groove, and that therefore there is here a kind
of joint.

I have seen in Prof. Gruber's clinic, a case which appeared
to have *two* short processes projecting from the upper end of the
manubrium. Such an appearance is explained by Prof. Gruber,
as the result of a dislocation or slipping upward of the entire
malleus, out of this cartilaginous groove; the upper of the " two
short processes" in such a case is the true bony short process,
whereas, the lower one is the aforesaid cartilaginous cap, moulded
over the short process and held in the original position of the
true short process by the membrana tympani. This condition,
Gruber calls subluxation of the cartilage from the short process.
Kölliicker[1] regards this *hyaline* cartilage as a remnant of the
cartilaginous malleus of fœtal life, and he thinks it is very
possible that the osseous malleus is formed about the cartilage, as
is the case in the *processus spinosus*, in which instance the layer
of connective tissue found by Gruber between the cartilaginous
groove and the malleus, and the comparatively easy separation
of the two from each other, becomes perfectly explicable; but
Kölliicker does not admit that there is a normally developed
and constant space between these two structures.

[1] Gewebelehre, p. 707.

The Membrana Propria: the fibrous or middle layer of the Membrana Tympani.—Having considered the anatomy and the inspections of the outer or dermoid layer, the anatomy of the middle or fibrous layer of the membrana tympani demands attention. The *membrana propria* can be subdivided into two distinct and delicate layers, viz., an *outer*, composed entirely of radiate fibres intimately connected with the dermoid layer of the drum-head; and an *inner* layer composed entirely of circular fibres, in close relation with the mucous membrane composing the internal layer of the membrana tympani. These sub-layers of the membrana propria are named, briefly, the radial layer, and the circular layer. The fibres composing the former arise from the annulus tendinosus and the upper wall of the auditory canal, and are inserted into the manubrium of the malleus, centring for the most part at its spade-like tip. The fibres composing the circular layer arise partly from the annulus tendinosus, but the majority of them arise from the substance of the membrana tympani itself (von Trœltsch). Some of them are inserted into the malleus.

Of the former kind, viz., those arising from the annulus tendinosus, Gruber says: "They form a very acute angle with the annulus tendinosus, assuming in their progress downward the course of the fibres of the circular layer." These fibres, Prof. Gruber thinks, have either been overlooked heretofore, or considered radial fibres. The circular fibres are most numerous a short distance from the periphery of the membrana tympani. The region of their greatest thickness is in the outer third of the membrane, where they are twice as numerous as the radial fibres; the thickness of the circular layer at this point being 0.026‴, while that of the radial layer is equal to 0.018‴ (Gerlach). They are much less numerous at the middle third of the membrane, and almost wanting at the central part of the drum-head. A knowledge of the arrangement of these fibres is important when considering pathological changes which may have taken place in the membrana tympani.

Prof. Helmholtz[1] thus accounts for the peculiar concavo-convex shape of the drum-head: "If the radial fibres of the membrana tympani were not united by transverse ones, they would

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[1] Mechanism of the Ossicles of the Ear and the Membrana Tympani, Eng. transl. by Buck & Smith, New York, 1873.

be stretched in a straight line. In point of fact, however, they maintain a curved shape, with the convexity looking toward the meatus ; hence we conclude that the radial fibres are drawn toward one another by circular fibres, and that the latter are also made tense at the same time. There is, in fact, in the membrana tympani at rest, no other force capable of holding the radial fibres in a curved position, except the tension of the circular fibres."

The Descending Fibres of the Membrana Tympani.—In addition to the two layers already described as forming the membrana propria, there is still another layer composed of descending fibres, first described by Gruber.

These fibres are external to the radial fibres, and arise from the upper segment of the annulus tendinosus, and, lying very close to each other, are inserted into the sides and median line of the cartilaginous groove already described.

The various layers of the membrana propria, *i. e.*, the three just described as the radial, circular, and descending fibres, are lightly bound together by a very delicate kind of connective tissue. On the other hand, they cling very firmly to the annulus tendinosus, cartilaginous groove, dermoid and mucous layers, as shown by Gruber.

Dentiform Fibrous Structure of the Membrana Tympani.—There is in the membrana tympani a set of fibres arranged in a peculiar way and first described and named by Gruber the dentiform fibrous structure[1] of the drum-head.

" They arise near the periphery, about in the middle of the posterior segment, pretty far apart, but as they proceed on their upward course in the posterior segment they approach each other, in order to divide again, at some distance from the manubrium of the malleus, into several branches, usually about three, which run in different directions, and are finally lost by intertwining with the fibres of the membrana propria."[2]

These fibres are not confined to the posterior segment, but traces of them are found throughout the membrana tympani.

At their peripheral portion they are between the two layers of fibres composing the membrana propria, but as they approach

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[1] Dentritisches Fasergebilde.
[2] Gruber, Studien über das Trommelfell, p. 85.

the centre they are in intimate connection with the mucous layer of the membrana tympani. These fibres are of tense connective tissue, closely resembling tendon. When treated with acetic acid, they exhibit the peculiar connective tissue corpuscles already alluded to as being found in the membrana propria.

Prof. Gruber further shows that the fibres entering into the composition of this structure, become most beautifully manifest when viewed by polarized light, when they appear much more brilliantly illuminated than the other tissues of the membrana tympani. Respecting the function of this structure we are told that in all probability it is an apparatus for relaxing the membrane, although it cannot be shown as yet that it is a muscular structure.

Constituent Elements of the Membrana Propria.—The labors of Toynbee, v. Trœltsch, Gerlach, and Gruber have added to the knowledge of the nature and dimensions of the constituent elements of the *membrana propria.*

It consists chiefly of connective tissue of that variety halfway between the ordinary fibrillated and the homogeneous connective tissue of Reichert as shown by Gerlach.

The fibres are 0.004''' broad and 0.002''' thick, and on account of their ribbon-like shape they were once supposed to be unstriated muscle fibres, which they are not.

On these fibres, certain peculiar spindle-shaped corpuscles are found.

They were once supposed to be peculiar to the membrana tympani, and have been called "corpuscles of the membrana tympani," or the "corpuscles of v. Trœltsch," after the observer who first drew attention to their existence.

They are, however, connective tissue corpuscles of Virchow. They are about 0.002''' long and from 0.005 to 0.010''' wide at their broadest part, with from two to three processes.

According to Gruber, these bodies are found in two varieties in the membrana tympani, viz., the spindle-shaped and the stellate variety.

The Internal or Mucous Layer of the Membrana Tympani.—The internal layer of the membrana tympani is composed of mucous membrane, a reflection of that lining the tympanic cavity. It is thickest at that point where it leaves the cavity of the mid-

dle ear and passes over the periphery of the drum-head. It grows gradually thinner as it approaches the centre of the membrana tympani, where it is extremely delicate.

On the inner surface of this layer various observers among whom may be named Politzer, Gerlach, and Kessel, have found villi or papillæ. They are said by Gruber to resemble intestinal villi in their appearance. They are usually found in delicate children. These villi may be globular or finger-shaped, the diameter of the former being from 0.10''' to 0.12''' and the length 0.12 to 0.14'''; the finger-shaped ones vary in length from 0.10 to 0.12''' and in width 0.06 to 0.08'''. (Gerlach and Gruber.)

Since Gerlach could not discover any nerves in these bodies, and as some of them are connected with the mucous membrane only by means of pedicles, he is disposed to regard them as villi rather than as papillæ.

Fold of Mucous Membrane for the Chorda Tympani.—The mucous membrane of the tympanic cavity covers the entire inner surface of the membrana tympani; at its upper boundary it is reflected over the chorda tympani and back again to the drum-head.

By this means a duplicature or fold of mucous membrane is formed, the opening of which is turned towards the surface of the membrana tympani, and in the cul-de-sac or inner edge of which the chorda tympani is found.

Pockets or Pouches of the Membrana Tympani.—This arrangement makes the so-called pockets or pouches of the membrana tympani, first described by v. Trœltsch. The mucous membrane, after passing over the chorda tympani and rejoining the drum-head forming these pouches, passes upward and is reflected inward over the roof of the tympanic cavity and the ossicles. Further explanation of the pouches will be given under the consideration of the contents of the tympanic cavity.

Fig. 14.
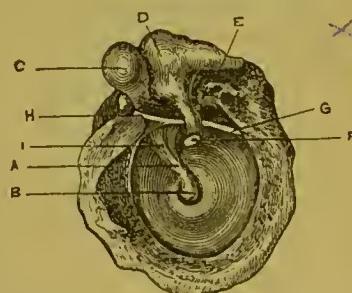
VIEW OF INNER SURFACE OF MEMBRANA TYMPANI. (Gruber.)—A. Manubrium of malleus. B. The tip or lower end of manubrium. C. Head of malleus. D. Body of incus. E. Short process of incus. F. Processus lenticularis of incus. G. H. Chorda tympani. I. Insertion of tensor tympani.

Comparative Distribution of Bloodvessels in the Membrana Tympani.—In a series of investigations upon the membrana tympani of the mammalia, I have found in the dog, the cat, the goat, and the rabbit, an arrangement of the bloodvessels not heretofore described, and totally different from that in man.

Prussak,[1] in his brochure upon the circulation of the blood in the tympanum of the dog, has represented the general topography of the vascular system in the membrana tympani of that animal, but it does not point out the ultimate *loop-like* arrangement of the vessels distributed over the surface of the membrane. The plate which accompanies his article seems to indicate that the delicate vascular loops have been broken by the force of injection, and thus escape the eye of the observer.

In my investigations I have found that from the periphery of the membrane a series of vessels run directly towards the manubrium of the malleus; then each vessel, a point from one-half to one-third of the distance between the periphery of the membrane and the manubrium of the malleus, turns *abruptly* upon itself and returns to the periphery, thus forming a series of *vascular loops* at nearly equal distances from each other around the edge of the membrane.

A similar series of loops run both anteriorly and posteriorly from the manubrium of the malleus towards the periphery of the membrana tympani, a diagram of which may be seen in Fig. 15, representing the membrana tympani of a dog magnified eight diameters.

This arrangement of vessels in the membrana tympani is constant in the dog, the cat, the goat, and the rabbit, in consequence of which a portion of the membrane between the annulus tympanicus and the manubrium of the malleus remains free from capillaries in its normal condition, and it is probable, though not yet proven, that ordinary disturbances in the circulation are likely to interfere with the vibrations of the membrane in these animals.

These vascular loops do not exist in the guinea-pig, an animal which has in its membrana tympani an arrangement of vessels peculiar to itself. The general appearance of the membrana

[1] Verhandlungen der Königlich Saechsischen Gesellschaft der Wissenschaften zu Leipsic, 1868.

tympani of the guinea-pig, under the microscope, is much more transparent and delicate than that of any of the previously mentioned animals.

Fig. 15.
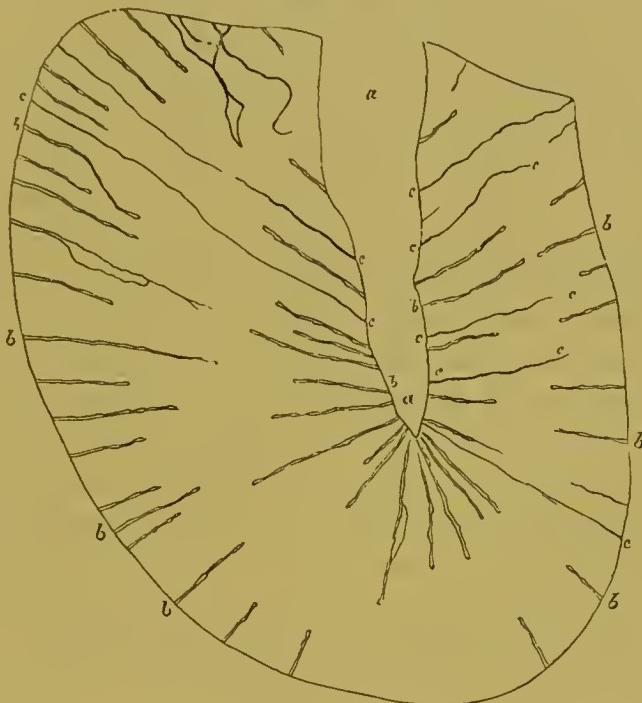
MEMBRANA TYMPANI OF A DOG.—The wood-cut is from a drawing of a gold preparation made by and in the possession of the author. *a, a.* Vacancy left by manubrium of malleus. *b, b, b, b.* Vascular loops. *c, c.* Ordinary capillaries.

The vessels are arranged in the form of a net, with coarse mesh of quadrangular or pentagonal shape. The radiate fibres are strongly developed in comparison with the circular fibres, which are sparsely distributed throughout the texture of the membrane. They are, however, readily seen, and present an appearance as peculiar to the membrana tympani of the guinea-pig, as the shape of the mesh of the network of bloodvessels in this animal. In no other membrane have I seen as distinctly the blood-corpuscles lying within the capillaries as in that of the guinea-pig.

The membranes which show these loops and other vascular arrangements most distinctly are such as have been colored with a solution of the chloride of gold ($\frac{1}{2}$ per cent). The vascular arrangement can be seen, but not very satisfactorily, in membranes which have been treated with osmic acid or a solu-

tion of carmine. The best specimens, showing not only blood-
vessels, but in many cases the delicate nerves of the membrane,
I have obtained by preparing the membrana tympani of the
dog in the following manner: Remove the membrane from the
animal as soon as possible after death. In the majority of
my experiments, the animal had been dead but a few minutes.
Steep the membrane a few seconds in concentrated acetic acid ;
then lay it in a solution of chloride of gold, which should be
kept at a temperature somewhat above that of the blood, for
one-half hour. After this treatment, the membrane should
remain twenty-four hours in glycerine, or water slightly acidu-
lated with acetic acid, and exposed to the light till it assumes
a delicate purple hue. The older the preparation becomes, the
more distinctly are the vessels colored. I have some prepara-
tions, mounted in glycerine, now almost a year old, which are
better than the day they were made, since the gold has taken
an increasing hold upon the tissues of the vessels and nerves.
After a number of trials, I prefer leaving the membrane in gly-
cerine acidulated with acetic acid, since it demands less care in
respect to renewal, and I am never chagrined at finding my
specimen destroyed by the evaporation of the water.

By this process the *loops*, and the nerves accompanying them,
are most likely to be rendered visible.

The arrangement of the nerves, not represented in the wood-
cut, is best described as fork-shaped. The prongs embrace the
loop ; the handle unites with a similar projection from the
opposite series of loops. As a rule, the vessels color more
readily under the action of chloride of gold than the nerves.

How this might be in clear weather, I am not prepared to
say, as all of my experiments were performed in the cloudy
weather of a Vienna winter, notwithstanding which, the nerves
frequently became richly colored.

This method of coloring vessels and nerves I have applied
only to the membrana tympani, and hence, I can claim no supe-
riority for it in connection with other tissues. When it succeeds,
it is superior to any injection of this very delicate membrane,
since the vessels and nerves are rendered visible with a distinct-
ness characteristic of the action of chloride of gold, a reaction
to which attention was first called by Cohnheim.

The bloodvessels are rendered distinct, without becoming

opaque, so perfectly in most cases that we can detect the blood corpuscles lying within the capillary.

The vessel, furthermore, retains its normal calibre and posi-tion, whereas, when we resort to injections, the vessels are apt to be unduly distended, are necessarily opaque, extravasation of coloring matter may take place, or the vessel may be ruptured.

The method is more convenient than injection, and as no mechanical force is used, the field of the microscope must of necessity present a very true picture of the tissues as they are in their normal state.

The application of this method of coloring to the membrana tympani of man shows the *absence* of the vascular loops already described, and reveals an arrangement of the vessels similar to that obtained by other observers with injections.

The arrangement of the vessels is not unlike the vascular network in the membrana tympani of the guinea-pig. In man, however, the mesh is much finer, the vessels coarser. The fibrous layer is, on the other hand, very thick, and is more equally composed of radiate and circular fibres than the mem-brane in the guinea-pig.

Since the membrana tympani of man is supplied by a dense network of vessels, the gold method of coloring it is superior to the usual method by injection, as the entire preparation is less opaque than when the vessels are filled with Prussian blue, carmine, etc.

It may, therefore, be concluded that :—

1. There is a distribution of vessels in the membrana tym-pani of man peculiar to him.

2. There is a distribution of vessels in the membrana tympani of the dog, the cat, the goat, and the rabbit, constant in, as well as peculiar to them.

3. A distribution of bloodvessels exists in the membrana tympani of the guinea-pig peculiar to it.

SECTION II.

MIDDLE EAR.

CHAPTER I.

TYMPANIC CAVITY.

ANATOMY.

UNDER the term Middle Ear are included the tympanic cavity and its two very important adjuncts—the Eustachian tube in front, and the mastoid portion of the temporal bone, and its cells, behind.

Ossicles of Hearing.—In the tympanic cavity of all mammals, are three small bones: the *malleus* or hammer; the *incus* or anvil; and the *stapes* or stirrup.

Anatomists of a latter day have shown that the once so-called *os orbiculare*, or *os Sylvii*, does not exist as a separate ossicle. That which once received this name is the *processus lenticularis* of the long process of the incus, which fits into a corresponding depression in the head of the stapes.

The Malleus.—The malleus, or mallet, received its name from Vesalius, and although some anatomists have failed to see the resemblance to this implement, the ossicle still retains its name, and is divided into head, neck, and handle. At the junction of the latter with the neck, are two important processes, viz.: the *short process*, which, when in its normal situation, pushes the membrana tympani ahead of it, and points towards the auditory canal, and the *process of Rau* or *Folius*, which passes anteriorly into the Glaserian fissure. In the foetus and new-born child, this process is about 3½ lines long, and can then be removed whole. After birth it unites with the under wall of the Glaserian fissure, and when the malleus is removed, only a short piece of the former long process is found attached to it. This

remnant was all that was known of the long bony process, to
the older anatomists, and it has been called the processus Foli-
anus,[1] after Folius, who, in describing this process, alluded only
to the remnant.

Fig. 16.
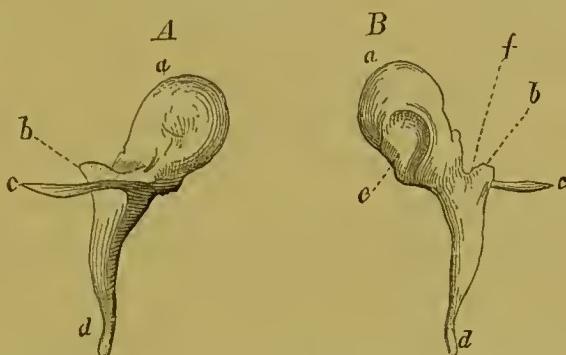
RIGHT MALLEUS: A, FROM IN FRONT; B, FROM BEHIND. (Magnified 4 diam.; Henlé.)—*a*.
Head. *b*. Short process. *c*. Long process. *d*. Manubrium. *e*. Articular surface. *f*. The neck.

This process, in its most perfect osseous state, was fully
described by Jacob Rau[2] in his lectures, and his pupils, Valen-
tin[3] and Boerhaave,[4] call him the discoverer of it.

Hence in its perfect state it is called the processus Ravii,
since Rau or Ravius was the first to describe the broad end
united to the Glaserian fissure. This process has also been
called the *processus longus seu spinosus*. It is united to the
Glaserian fissure, in adults only, by a mass of ligamentous tissue,
which favors slight motion in any direction.

The *head* and *neck* of the malleus project into the tympanic
cavity, and are entirely free from the membrana tympani.
The rounded, smooth surface of the head is directed anteriorly,
while the surface which articulates with the incus is directed
backward. The long diameter of its articular surface runs
vertically, the short diameter horizontally.

In the direction of the former, the articulating surface has
been said to resemble a saddle, for the surface is divided a little
below the middle by a horizontal ridge, and depressed on each

[1] Caelius Folius, Venice, 1645. Nova auris internæ delineatio.
[2] Jacobus Ravius, Professor of Anatomy and Surgery in the University of
Leyden.
[3] 1719.   [4] Prælectiones, p. 358.

side of it. This articulating surface is also concave in the direction of its short diameter, $i.\ e.$, from without inward.

If a shallow oval basin, the long diameter of which is considerably greater than its short diameter, be placed across a ridge, and then bent downward, and at the same time slightly twisted on itself, the cavity thus formed will fairly represent the articulating surface of the malleus.

The $neck$ of the malleus lies between the head and the manubrium. It makes, with the former, an angle of about 135° when viewed from in front. It has three surfaces: a $broad\ inner$ one directed towards the tympanic cavity, bounded in front by the processus Ravii, or long process, and behind by the long, low bony elevation for the insertion of the tendon of the tensor tympani; $an\ anterior\ surface$, lying above the ridge joining the processus brevis and the processus longus, and extending to the angle made by the head of the malleus with the neck, and separated from the posterior surface by a sigmoid-shaped ridge for the insertion of the ligamentum mallei externum of Helmholtz. The $posterior\ surface$ lies between the aforesaid sigmoid ridge in front, the edge of the articulating surface of the malleus above, the low, long process behind, and a line drawn from the insertion of the tensor tympani to the short process below. Of all the surfaces of the neck, the posterior glides most gradually into the manubrium. The $handle$ or the $manubrium$ of the malleus, that part of the bone inserted into the membrana tympani, has also three surfaces, which may be considered prolongations downward of those of the neck. Since they all gradually approach each other and are united in the tip or point of the manubrium, the latter may be said to resemble a three-sided bayonet, one ridge of which passes from the short process directly downward to the tip, and is consequently turned towards the external auditory canal. The point or lower end of the handle of the malleus is flattened into a small disk, one surface of which is turned towards the auditory canal. This spot is plainly visible as the pale, round centre of the umbo.

The long axis of the handle of the hammer is convex posteriorly and inward, so that when viewed from without the manubrium appears concave on its anterior and outer surfaces. This is especially marked at the lower third on the anterior surface, so that the manubrium normally appears curved de-

cidedly forward near its lower end, of course in the plane of the membrana tympani. Along the ridge of the manubrium, directed towards the external auditory canal, several little node-like prominences are not uncommonly seen. These are not pathological, but purely normal. Their origin is obscure.

Dr. A. H. Buek[1] has described a hook-shaped termination anteriorly, of the manubrium mallei in a boy thirteen years old. The manubrium of the opposite side had been destroyed by otorrhœa, so that it was impossible to make a comparison between the mallei in this case.

Dimensions of the Malleus —The malleus is nearly 9 mm. long; its manubrium is between 4 and 5 mm. long, and its head is $2\frac{1}{2}$ mm. thick. The latter is the greatest diameter of any part of the bone, which gradually tapers to the point of the handle.

The long diameter of the articulating surface of the malleus is about 3 mm.; the short diameter is between $1\frac{1}{2}$ and 2 mm.

Fixation of the Malleus.—The malleus is held in position by four ligaments, viz.: Ligamentum mallei anterius, ligamentum mallei superius, ligamentum mallei externum, and the ligamentum mallei posterius. The *ligamentum mallei anterius* is a broad band of fibres which holds the processus Folianus against the spina tympanica major. This ligament may be said to arise from the spina tympanica major and to be inserted along the neck of the malleus all the way from the processus Folianus to the head of the malleus. A part of it also runs from the processus Folianus to the short process of the malleus below, and the membrana tympani above, forming thereby the division between the anterior and posterior pockets of the membrana tympani ; another fold of the same ligament runs from the processus Folianus downward with a free margin, as far as the line corresponding with the insertion of the tensor tympani muscle. This makes the limit between the anterior pocket of the drum-head and the tympanic cavity.

The round *ligamentum mallei superius* descends obliquely downward and outward from the tegmen tympani to the head of the hammer. Its function is to prevent the malleus from being forced outward.

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[1] N. Y. Med. Record, Dec. 16, 1872.

The *ligamentum mallei externum* is a very important collection of satin-like, tendinous fibres, which radiate from the sigmoid crest on the front of the neck of the hammer and are inserted into the sharp edge of the segment of Rivinus on the temporal bone. It prevents the hammer from being forced inward, and being inserted above the axis of rotation of the hammer, it prevents the manubrium, which is below the axis of rotation, from moving too far outward towards the auditory canal.

The *ligamentum mallei posticum* is really the posterior edge of the ligament just described as the external ligament of the hammer. As the line this bundle of fibres follows passes through the spina tympanica major, and as it represents pretty closely the axis of rotation of the hammer, Helmholtz has suggested it should be considered a separate ligament, and has given to it the name it bears.

As this ligament and the ligamentum anterius are in a mechanical sense one ligament, although the hammer intervenes between them, Helmholtz has called the two sets of fibres the axial ligament of the malleus.

Axial Ligament of the Malleus.—The plane of this ligament is not quite horizontal, being a little higher in front than behind.

In all its motion as a lever the hammer swings about this axis-ligament as a fixed point. All above the short process of the malleus is above, and all below the short process is below, the axis-ligament.

The *ligamentum mallei anterius* of Arnold was once described as a muscle, the laxator tympani major.[1] It is not, however, anything more than a ligament which originates from the spina angularis of the sphenoid, passes through the petro-tympanic fissure,[2] and is inserted into the malleus.

Under the name of *ligamentum mallei posticum seu manubrii*, the *ligamentum mallei externum* of Arnold, Lincke describes a ligament which passes from the upper edge of the end of the external auditory canal to the short process of the malleus, and occupies the position of a supposed muscle, once called the M. laxator tympani minor, or M. mallei exterior seu Casserii. It is

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[1] Sömmering.   [2] Glaserian fissure.

now universally acknowledged that muscular fibres do not exist here.[1]

Fig. 17.
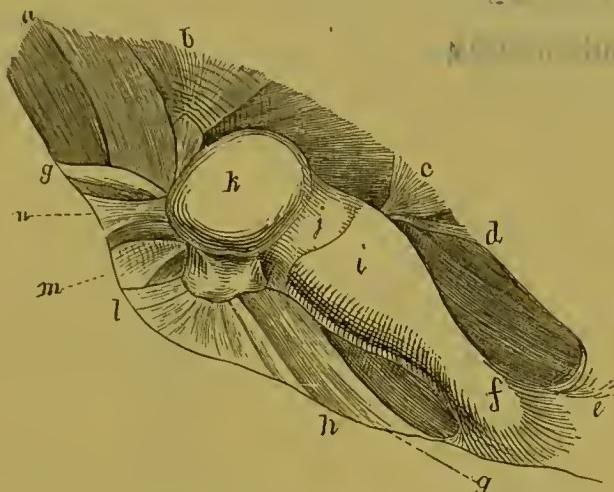
LIGAMENTOUS SUPPORT OF OSSICLES VIEWED FROM ABOVE. (Helmholtz.)—*l–h*. Attachment of the ligamentum mallei externum. *k*. Head of hammer. *i*. Body of incus. *f*. Point of its short process. *a*. Entrance to the Eustachian tube from the tympanum. *c*. Stapes. *d*. Tendon of its muscle. *b*. Tendon of the tensor tympani, leaving the cochlear process. *g–g*. Chorda tympani, marking the free edge of the folds of mucous membrane, bounding the pouches. *n*. The upper tendinous fibres of the ligamentum mallei anterius, originating above the spina tympanica major, *m*. *j*. Malleo-incudal joint.

Incus or Anvil.—The middle one of the three auditory ossicles is the incus or anvil. The name is derived from the shape of its upper half. This small bone is divided into a body and two processes, viz., a short and long one. The former of these two processes is also called the horizontal process. It is held to the posterior and to the upper wall of the tympanic cavity by ligaments.[2] (Fig. 18, *e*.) This is an important point in the mechanism of the auditory ossicles.[3] The longer process is also called the descending ramus of the incus. It curves gradually outward, *i. e.*, towards the external ear, away from the vertical plane of the body of the incus, assuming a slight sigmoid shape; at its tip it curves rather sharply inward, to unite with the head of the stapes by means of the processus lenticularis.

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[1] Henlé, Eingeweidelehre, p. 745.

[2] Ligamentum incudis posterius et ligamentum incudis superius.

[3] Henlé calls this the incus-tympanic joint, "an amphiarthrosis between the articulating surface of the short process of the incus, and a prominence on the posterior wall of the tympanic cavity. The articulating surface on the incus is covered with a thin layer of fibrous cartilage."

The narrowest part of the incus is at the middle of the body
of the bone; beneath this part it widens out again anteriorly
into the important tooth which locks with the malleus in all its
inward movements, and posteriorly into the descending ramus
or long process. The articulation between the malleus and
incus is a true joint, in which is found a meniscus.[1]

Fig. 18.
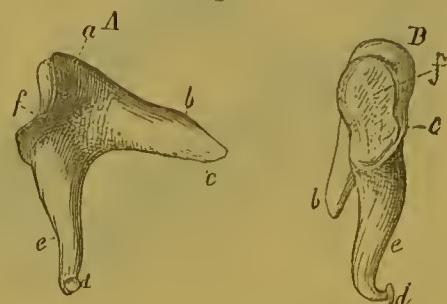
RIGHT INCUS. (Magnified 4 diam.: Henle.)—*A*. Inner surface. *B*. View in front. *Aa*. and *Bc*.
Body. *b*. Short process. *e*. Long process. *d*. Processus lenticularis. *f*. Articular surface for the
head of the malleus. *c*. Surface which lies in contact with wall of tympanic cavity.

If this articulation is viewed on its outer surface, *i. e.* on that
side towards the external auditory canal, it would seem that
the incus quite overlapped or embraced the head of the malleus;
when viewed from its tympanic side, however, it appears that
the largest share in the joint belongs to the malleus. This is
due to the wonderfully peculiar structure of this joint, the
true nature and function of which were first pointed out and
explained by Helmholtz in 1869.[2]

Dimensions of the Incus.—The greatest length of the incus is
in a vertical line passing from the top of the body of the bone
through the long process. It measures 7 mm. The horizontal
upper edge of the body measures 5 mm. Its greatest thickness,
$2\frac{1}{2}$ mm., is at its articulating surface for the malleus.

Malleo-Incudal Joint.—Before Helmholtz's investigations, the
shape of this articular surface was usually described as resem-
bling a saddle. In order to gain a clearer idea of the mechanism

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[1] Rüdinger.

[2] Mechanik der Gehörknöchelchen und des Trommelfells, Bonn ; also Pflü-
ger's Archiv f. Physiologie, 1 Jahrgang.

of this joint, Helmholtz makes use of a different comparison. "It is, in fact, like the joint used in certain watch-keys, where the handle cannot be turned in one direction without carrying the steel shell with it, while in the opposite direction, it meets with only slight resistance. As in the watch-key, so here, the joint between hammer and anvil admits of a slight rotation about an axis drawn transversely through the head of the hammer toward the end of the short process of the anvil; a pair of cogs oppose the rotation of the manubrium inward, but it can be driven outward without carrying the anvil with it."[1] It is of the kind of joint known as ginglymus. The mechanism of this joint is best understood when it is known that the malleus, as a whole, is a lever, the fulcrum of which passes just below the short process. This, of course, leaves the head and neck, *i. e.* the articulating surfaces for the malleo-incudal joint and all the free tympanic parts of the malleus, above the line of support of the lever, the manubrium being below. The latter is the long arm of the lever, and consequently all its movements are repeated in an opposite direction on the head of the malleus. Each inward movement of the manubrium, therefore, causes a slight outward motion in the head of the malleus and a firm locking of the malleo-incudal joint, by which the incus is carried about an axis drawn transversely through the head of the hammer toward the end of the horizontal or short process of the incus. The incus being also suspended as a lever, about the line just named, when all above that line moves outward, all below the line moves inward, *i. e.*, as the upper part of the incus is moved outward the long process swings inward and carries the stapes ahead of it, thus forcing the foot plate of the latter into the oval window.

The Stapes or Stirrup.—The smallest bone in the body and the innermost of the three auditory ossicles is the stapes or stirrup. Its name is derived from the striking resemblance it bears to a stirrup. It is divided into a head or capitulum, a neck, two branches or legs (crura), and a foot-plate or *basis.*

The *head*, which is really a cup-shaped button, is placed at

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[1] Helmholtz's Mechanism of the Ossicles of the Ear, etc., English translation by Buck and Smith, 1873, p. 33.

the junction of the two crura.   It is designed for the reception
of the processus lenticularis of the incus, with which it forms
a ball-and-socket joint.   There is a meniscus in this joint
according to Rüdinger.[1]   On the posterior surface of the head
of the stapes the stapedius muscle is inserted.

Fig. 19.

RIGHT STAPES. (Magnified 4 diam.: Henlé.)—*A*. From within. *B*. From in front. *C*. From
beneath. *b*. Foot-plate or base. *d*. Capitulum. *c*. Anterior, *a*, posterior shaft or crus of stapes.

The two *crura* or *branches* are furrowed on their inner surface,
which makes them lighter, yet does not deprive them of strength.
They arise from the *basis* forming a graceful arch and unite
above in the *head*, as already stated.

The *foot-plate* of the stapes is oval or slightly kidney-shape,
thicker at the periphery than in the centre, is slightly convex
towards the vestibule, and concave on its tympanic surface; it
fits into the oval window, where it is held by a fibrous packing.
This permits of a slight inward and outward movement on the
part of the base of the stirrup.   When the stapes is in position,
the long axis of its base is horizontal and coincides with that
of the oval window.   In this position its convex edge looks
upward, and its concave edge, which gives it its slight kidney-
shape, looks downward.

The *ligamentum obturatorium stapedis* is a thin membrane
stretching across the space between the base and the crura; it is
attached to the crista of the former and the furrow on the inner
edges of the latter.[2]

Dimensions of the Stapes.—The stapes measures nearly 4 mm.
from its head to the under surface of the foot-plate.   The latter
is $2\frac{1}{2}$ mm. long in its horizontal diameter, 1 mm. in its vertical

[1] Virchow's Archiv, Bd. xx. 1860.   Monatsschr. f. Ohrenh. Jan. 1873.
[2] Rüdinger, Atlas of Osseous Anatomy of Human Ear, edited by Blake,
Boston, 1874, p. 9.

diameter (the bone of course must be imagined in normal position), and about ¼ of a millimetre thick, at its edges. It is slightly concave towards its centre.

Joint between Base of Stirrup and Oval Window.—According to Helmholtz,[1] the base of the stapes is surrounded at its edge by a lip of fibro-elastic cartilage 0.7 mm. thick. The union between the base of the stirrup and the wall of the labyrinth appears to be formed by means of the periosteum of the vestibule, extended over the base of the stapes (Henlé), but the fibrous lip on the edge of the base of the stirrup is not attached to the fenestra ovalis. The mucous membrane of the tympanic cavity extends over the outer or tympanic surface of the base of the stapes.

In 1869 Dr. A. H. Buck examined very closely the fixation of the base of the stirrup in the oval window, and made the following conclusions:—[2]

1. The base of the stapes is fastened to the edge of the round window by a ligament or elastic fibres. 2. The fibres of the ligament gradually converge towards the edge of the base of the stapes. 3. The ligament arises from the periosteum in the neighborhood of the oval window and passes over to the base of the stirrup, where it again assumes the function of periosteum. 4. The breadth of the ligament is the same all around the periphery of the base of the stapes.

Dr. Gustav Brunner,[3] of Zurich, regards the malleo-incudal and incudo-stapedial joints as a variety of symphysis or synchondrosis. He is disposed to regard the connections between the ossicula auditus not as true or ordinary joints. As described by him, they are all of peculiar construction, since between the cartilaginous surfaces of the bones there is a fibrous or fibro-cartilaginous intermediate substance.

Dr. Rüdinger[4] reasserts the true joint-like structure of the articulations of the ossicula. He also maintains his view that in both the malleo-incudal and incudo-stapedial joint there is a

[1] Op. cit., pp. 34–35.

[2] Archiv f. Oph. and Otol. von Knapp u. Moos., 1 Band. Carlsruhe, 1870.

[3] Ueber die Verbindung der Gehörknöchelchen, namentlich, des Hammer-Ambossgelenks, Vorläufige Mittheilung. M. f. O. No. 1, 1872.

[4] Ueber die Gelenke der Gehörknöchelchen, M. f. O. No. 3, 1872.

fibro-cartilaginous disk connected with the capsular ligament, but not with the hyaline covering of the articular surfaces of the bones.

Dimensions of the Ossicula Auditus.—Urbantschitsch,[1] by comparing the auditory ossicles of 50 different tympana, found that the *malleus* varied in length from 7.0–9.2 mm.; the average length is 8.5 mm. The *short process* varies from 1.2–2.6 mm., with an average length of 1.6 mm. The *long process* (the Folian process) was found in one case, an individual 30 years old, to be 2.5 mm., and in another, a man 20 years old, 5.8 mm. long. The *manubrium* has an average length of 5.0 mm. from the short process to the point.

In the *incus*, the distance of the upper end of the articular surface from the free end of the horizontal ramus is, on the average, 5.3 mm. The under end of the surface of the joint is 4.6 mm. distant from the incudo-stapedial joint. The incus is the most porous of the ossicles. The average length of the *stapes* is 3.7 mm.; its average breadth between the rami, 2.3 mm. Its head is either entirely straight (29 times), or else inclined towards the anterior (18 times) or posterior (3 times) limb; in one case the head pointed upward, *i. e.* towards the upper edge of the foot-plate of the stapes. The entire paper of Dr. Urbantschitsch will amply repay a careful reading.

According to the investigations of Dr. C. J. Blake,[2] the weight of the ossicula auditus varies greatly with the age and individual. It is also worthy of note that the proportionate weight of the ossicula, one to another, is not constant. Dr. Blake states that in the new-born child, the proportionate weight of the malleus to the incus is generally as 20 to 17, and in a malleus weighing 20 milligrammes, the weight would be distributed as follows: "the capitulum mallei, including that portion of the neck just above the processus brevis, 16 milligrammes; the processus longus, including the processus brevis, 4 milligrammes."

"In an incus weighing 17 milligrammes, the corpus incudis, including the processus brevis and the base of the processus

[1] Archiv für Ohrenheilkunde, Band. xi. p. 1–11.

[2] Distribution of Weight in the Ossicula Auditus. Transactions Amer. Otol. Soc., vol. i. p. 543.

longus as far downward as the lower lip of the inferior articu-
lating surface, 14 milligrammes ; and the processus longus, with
the os lenticulare attached, 3 milligrammes, the corresponding
stapes weighing very nearly 4 milligrammes. In the adult, the
weights of the malleus and incus are, as a rule, more nearly
equal ; in some cases, however, the proportionate weight of the
malleus to the incus is as 7 to 8."

The distribution of weight above and below the axial line—
the line about which the malleus tends to swing (see p. 72)—is
as follows, according to the investigations of Dr. Blake : In a
malleus which weighed 21 milligrammes, and the incus 25 milli-
grammes, the combined weight of the portions of these two
bones, above the axial line, the line of section in the experi-
ments, was 30 mg. ; that below the line, 16 mg., or in the pro-
portion of 15 to 8. This preponderance of weight in the parts
of the malleus and incus above the axial line, tends to act as a
mechanical counterbalance, and renders the two bones better
able to vibrate upon the axial line. It also serves to increase
the delicacy of a mechanism which responds to sound-waves in
excursions so infinitesimal that the highest powers of the micro-
scope cannot render them visible, as shown by Helmholtz.

The Tympanum.—The tympanic cavity is about half an inch
in height and width and a line or two deep, measuring from
within outward. It is lined with mucous membrane, which is
reflected over all the tympanic contents, and is a continuation
of that of the throat, nose, and Eustachian tube. The drum
cavity lies entirely within the temporal bone, and is bounded
by a roof and floor, and the four walls.

The *roof*, or tegmen tympani, is the boundary between the base
of the brain and the tympanum. This osseous partition is very
thin, and in some cases congenital fissures in it persist ; in such
instances the only boundary at the dehiscences, between the
tympanum and the cerebral cavity, is formed by the mucous
membrane of the former and the membranes of the brain. It is
evident that in such cases, pathological processes in the drum-
cavity are especially liable to pass upward to the brain.

*The Malleo-incudal Joint and surrounding parts viewed from
above.*—If the tegmen tympani be removed, let us say, from the

right tympanic cavity, the malleo-incudal joint and the incudo-tympanic joint will be laid bare, and just in front of the head

Fig. 20.

RIGHT TYMPANIC CAVITY VIEWED FROM ABOVE; MALLEO-INCUDAL AND INCUDO-TYMPANIC JOINTS. (Magnified 2 diam.; Henlé.)—*c.* Head of malleus. *e.* Short process of incus. *f.* Tendon of tensor tympani muscle. *d.* Capsule of incudo-tympanic joint. *a.* Ligamentum mallei anterius. *b.* Chorda tympani.

of the malleus, but below it, will be seen the tendon of the tensor tympani muscle coming upward and inward from the left, to be inserted into the tubercle on the neck of the hammer. Above this tendon, winding from within outward and to the right, around the neck of the malleus, is seen the chorda tympani, a branch of the facial nerve, on its way to the Glaserian fissure. Of course this picture is to be reversed for the left ear. The suspensory ligament of the malleus is attached to the roof of the tympanic cavity.

The Floor of the Tympanum.—The floor of the tympanum is not much more than a groove between the outer and inner wall. It is below the lower periphery of

Fig. 21.
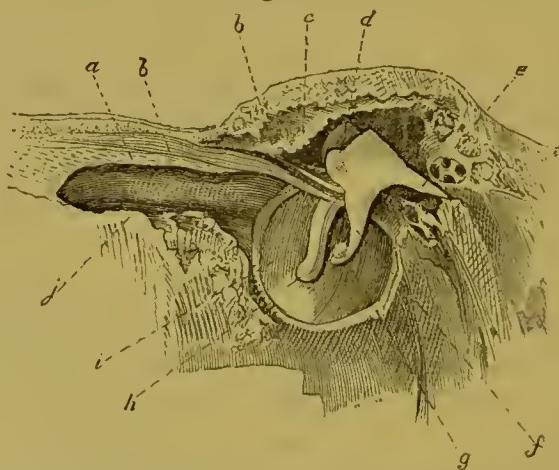
INNER SIDE OF THE OUTER WALL OF THE RIGHT TYMPANIC CAVITY; HAMMER AND ANVIL IN SITU; CANALIS MUSCULO-TUBARIUS LAID OPEN. (Magnified 2 diam.; Henlé.)—*b b.* Tensor tympani. *d.* Head of the malleus. *h.* Tip of the manubrium mallei. *e.* Short, *f.* long process. *g.* Processus lenticularis of the incus. *c.* Chorda tympani. *a.* Septum tubæ. *j.* Eustachian tube. *i.* Membrana tympani.

the drum-head, the opening of the Eustachian tube, and the opening in the mastoid cells. It is entirely within the boundary

of the petrous portion of the temporal bone and above the jugular fossa.

The outer Wall of the Tympanum.—The outer wall of the tympanic cavity is composed mainly of the membrana tympani. The bony framework of the annulus tympanicus around the membrana tympani, constitutes the limit of the outer wall of the tympanum. In connection with the outer wall, *i. e.*, in it or on it, we find the manubrium mallei, the chorda tympani, and the duplicature of mucous membrane about it, which also forms the so-called pockets of the membrana tympani.

The pockets or pouches of the membrana tympani are the duplicatures of mucous membrane around the chorda tympani in the horizontal portion of its passage through the tympanic cavity. They were first described by von Troeltsch, in 1856,[1] and are situated on the inner side of the upper part of the drum-head.

The *posterior* pouch lies between the malleus and the posterior periphery of the membrana tympani, and is the larger of the two. It contains in its structure fibres of the fibrous layer of the drum-head. The shape of the posterior pouch is triangular or tent-like, the apex of which is directed inward, and its base outward. It is about 3 mm. high, and 4 mm. broad. This pouch is best seen when the inner side of the drum-head is viewed, but it can also be seen from the outer side, when the drum-head is thin and properly illuminated.

The *anterior* pouch lies in front of the malleus, and is smaller than the posterior pouch. It is composed of mucous membrane only. It is not so well marked as the posterior pouch, but contains " all the parts which proceed from or enter the Glaserian fissure."[2] It is much lower and shorter than the posterior pouch.

There is a third pocket or pouch of the membrana tympani described by Prussak[3] and Gustav Brunner.[4] This cavity is bounded behind by the neck of the malleus, below by the upper

[1] Würzburg Transactions.

[2] See Roosa's translation of v. Troeltsch on the Ear, N. Y., 1869, pp. 32–33.

[3] Archiv für Ohrenheilkunde, vol. iii.

[4] The Connections between the Ossicles of Hearing. Archives of Oph. and Otol., vol. iii. pp. 145–172, 1874.

surface of the short process of the hammer, in front by the
membrana flaccida, and above by a ligamentous band, the liga-
mentum mallei externum, which is inserted between the margo
tympanica and the spina mallei. This cavity is separated from

Fig. 22.
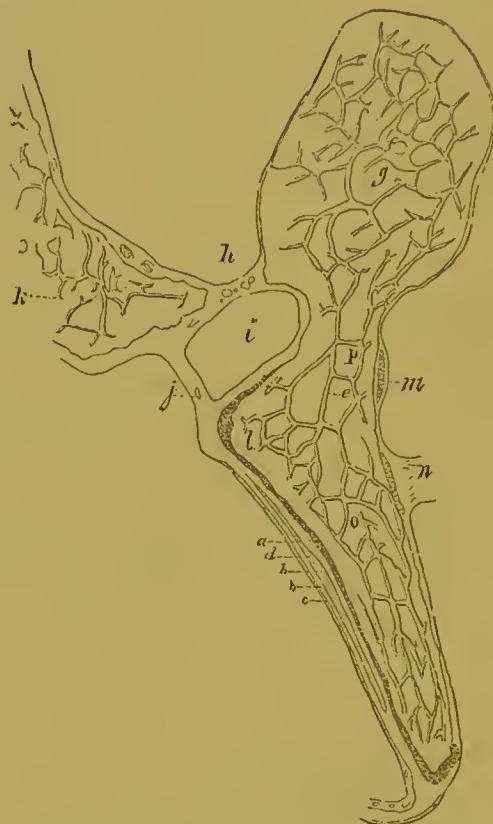
SECTION THROUGH THE LONG AXIS OF THE MALLEUS AT RIGHT ANGLES TO THE MEMBRANA
TYMPANI, FROM AN ADULT. (Brunner.)—*k*. Bony ridge at the upper segment of the drum-
head. (The segment of Rivinus, according to Helmholtz.) *g*. Head of malleus. *p*. Neck of
malleus. *o*. Handle of malleus. *l*. Short process. *j*. Membrana flaccida. *h*. Lig. mallei externum.
m. Chorda tympani. *n*. Tendon of tensor tympani. *i*. A cavity according to Prussak. *a*. Carti-
lage. *b, b*. Fibres of the membrana tympani. *c*. Dermoid layer of membrana tympani. *e*. Haver-
sian canals. *f*. Medullary space.

the anterior tympanic pouch by the upper blind end of the
latter; posteriorly, it communicates with the tympanic cavity
by a good-sized opening, above the position of the posterior
tympanic pouch. This pouch, being thus placed in communica-
tion with the tympanum, may become filled with mucus or pus,
and it may, in consequence, be ruptured.

Many cases of earache, which present no features of disten-
sion of the drum-head proper, nor, in fact, of the region of the

membrana flaccida, may be relieved instantly by puncturing the latter at the third pouch. The point of the puncturing in such cases is just above and in front of the short process.

As a general rule, when there is great earache, attended only by redness of the flaccid part of the drum-head, and neither congestion nor bulging of the drum-head proper, a cut into the congested flaccid part will relieve, in most cases, the suffering. Mucus or pus will usually escape ; sometimes only blood.

Inner Wall of Tympanum.—On the inner wall of the tympanic cavity there is found a convexity, the promontory caused by the projection outward at that point of the lower turn of the cochlea. This eminence is usually seen through the membrana tympani, as a pale yellowish spot. At this point the inner and outer walls of the tympanum are closest to each other. Above the promontory, in a depression named the *fossula fenestræ ovalis*, of Rüdinger, is the oval window, *fenestra ovalis*, which receives the foot-plate of the stapes. Behind the promontory is the

Fig. 23.
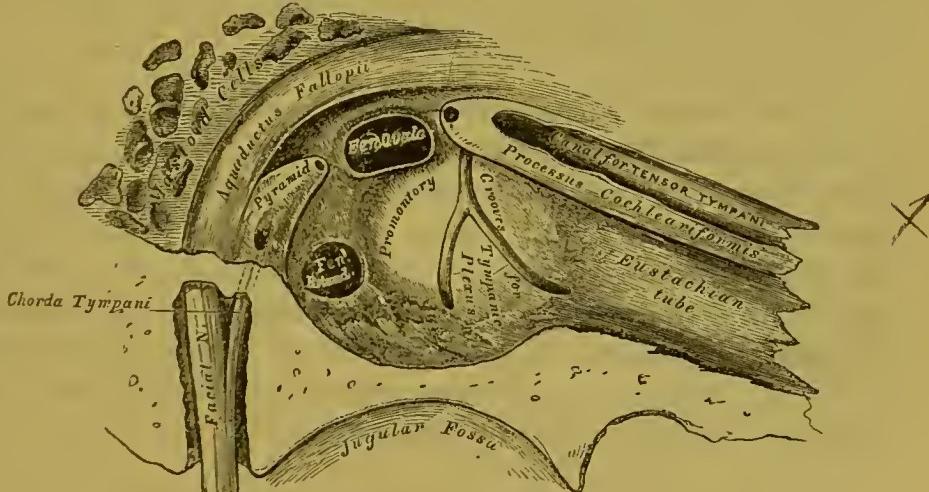
INNER WALL OF TYMPANIC CAVITY. (Gray.)

niche in which is found the round window, *fenestra rotunda*. The long diameter of the oval window is 3 mm., and its short diameter 1.7 mm. The diameter of the round window is 2 mm. A ridge starts above the oval window and curves backward and downward behind the promontory and round window. This ridge is the posterior limit of the inner wall of the tym-

panum, and marks the position of the canal for the facial nerve, which escapes from the tympanum at the stylo-mastoid foramen. The course of the facial nerve will be considered further on.

Eminentia Stapedii.—Behind, and a little below the line of the oval window, is a bony eminence, the *eminentia stapedii.* This little conical eminence is hollow and contains the stapedius muscle, to which it gives origin. The tendon of this muscle, after passing through a small opening in the apex of the eminence, runs a little upward and forward, forming an obtuse angle with the long axis of the muscle, and is then inserted into the edge of the articular surface of the head of the stapes.[1] The stapedius muscle is supplied with a branch from the facial nerve.

Function of the Stapedius Muscle.—According to Henlé,[2] it is probable that the stapedius muscle serves to hold the stapes in a firm position rather than to move it, and that it acts only when there is danger that an undue force communicated to the malleus will be conveyed to the stapes by means of the intervening incus. Its action then is to prevent the stapes from being forced into the oval window.

Fixator Baseos Stapedis.—Rüdinger has described an organic muscular structure on the tympanic surface of the stapes, which he calls the *fixator baseos stapedis.* It arises from a small bony ridge (diameter 0.80 mm.) situate one millimetre from the upper and posterior circumference of the oval window, and is inserted into the angle formed by the leg of the stapes and its somewhat projecting foot-plate. It is supposed to be an antagonist of the voluntary muscle, the stapedius, and prevents the latter from forcing the stapes too far into the vestibule.[3]

Topographical Relation of the Stapedius Muscle to the Facial Nerve.—Prof. A. Politzer[4] has added greatly to the knowledge respecting the relation of these parts to each other. In the

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[1] Henlé.   [2] Eingeweidelehre, p. 749.
[3] Das häutige Labyrinth, by Rüdinger, Stricker's Handbuch. pp. 912-913, 1872.
[4] Prof. Politzer, Zur Anatomie des Gehörorgans, I. Ueber das Verhältniss des Musc. Stapedius zum nervus facialis, II. Ueber den Processus Styloideus, Archiv f. Ohrenh., cap. ix p. 158.

fœtus only the upper part of the stapedial cavity is separated
from the facial canal by bone, the lower part having free com-
munication with the canal. At this point, the soft tissues sur-
rounding the muscle and the nerve are in contact. In the adult,
however, the communication between the bony cavity contain-
ing the muscle and the facial canal is less free, being effected
by means of one or more small openings or by one long slit-like
aperture 3–5 mm. long, and ½ mm. wide. Transverse sections
of this muscle show that it is a triangular prism ; longitudinal
sections show that its general form is pear-shaped.

In addition to the anatomy, Prof. Politzer has added to the
knowledge of the physiology of the stapedius muscle. He
shows that this muscle acts as a laxator of the membrana tym-
pani, and, as far as its effects upon the labyrinth are concerned,
it diminishes the pressure in that cavity by drawing the stapes
out of the oval window.[1] The oval window is separated from
the round window by the tract of bone corresponding to the
posterior surface of the promontory. They are about two milli-
metres apart. The plane of the former looks outward, and is
nearly vertical in its position; that of the latter looks backward
and downward. The oval window is the entrance to the vesti-
bule and mediately to the cochlea. The round window is an
exit from the cochlea into the tympanic cavity. This window,
however, in its normal state, is hermetically closed by a mem-
brane, the membrana tympani secundaria, or membrana fenestræ
rotundæ.

Well forward, on the inner wall, towards the tympanic open-
ing of the Eustachian tube, are the *processus cochleariformis*, the
spoon-shaped tympanic end of the *septum tubæ*, which separates
the Eustachian tube from the bony furrow containing the tensor
tympani muscle, and the tendon of the latter as it passes to
the malleus. The *processus cochleariformis* is the fulcrum over
which the tendon of the tensor tympani plays.

Tensor Tympani Muscle.—This muscle originates from the
anterior mouth of the *canalis musculo-tubarius* of the pyramidal
portion of the temporal bone, the upper wall of the cartilage of
the Eustachian tube, and from that small portion of the sphe-
noid bone which joins the temporal bone, the processus angu-

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[1] Loc. cit., p. 162.

laris. The muscle then passes over the *septum tubæ* and enters the canalis tensoris tympani.[1] Its tendon passes over the processus cochleariformis, and turning outward, crosses the tympanic cavity at right angles to the belly of the muscle, to be inserted into the malleus. The tensor tympani is connected with the dilatator tubæ or tensor palati, by both tendinous and muscular fibres, as shown by Kessel, Rüdinger, Mayer, Rebsamen and others. The motor nerve of the tensor tympani is derived through the otic ganglion[2] from the motor root of the trigeminus.[3]

The tensor tympani muscle has been described as a penniform muscle,[4] in allusion to its appearance, which is due to the fact that the muscular fibres arise from the periosteum of the upper wall of the bony canal in which the muscle lies, and pass into the tendon which lies on the under edge of the muscle; the latter is turned towards the floor of the canal. As the fibres of the muscle are short, a large portion of the tendon is within the canal. Within the canal the muscle is covered by a periosteal sheath, which is continued over the free portion of the tendon, crossing the tympanic cavity, and is there covered with mucous membrane. This sheath of the free tympanic part of the ligament, Toynbee called *the tensor ligament of the membrana tympani*. Helmholtz has found that in some cases the ligament is movable within this sheath, as described by Toynbee; on the other hand, Henlé has never found them entirely separate, nor differing from similar fibrous structures of other tendons. In any event, the play of the tendon within the sheath cannot be very great, on account of the slight motions of the malleus, as shown by Helmholtz.

The transverse section of a perfect tensor tympani muscle measures $2\frac{3}{4}$ mm., the length of its tendon from the processus cochleariformis to the insertion into the malleus is $2\frac{1}{4}$ mm., and the length of the muscle from its extreme origin on the Eustachian tube to the turn of the processus cochleariformis is 2.2 centimetres, somewhat more than an inch, as shown by Weber-

[1] This canal is not always perfectly closed, and hence it has been called the semi canalis tensoris tympani.

[2] Henlé, Eingeweidelehre, p. 747.

[3] Ludwig and Politzer, Meissner's Jahresbericht, 1860, p 583.

[4] Helmholtz.

Liel. The tendon of the tensor tympani is inserted on the anterior surface of the inner edge of the manubrium, rather than on its posterior surface; hence, traction inward of the muscle will bring about a rotation of the malleus about its long vertical axis, and thus twist the posterior surface of the handle of the malleus outward, and with it the posterior segment of the membrana tympani. It therefore often seems, in certain pathological retractions of the malleus, that the anterior segment of the membrana tympani is sunken, and that the anterior outline of the manubrium is especially prominent.

Anterior and Posterior Walls of Tympanic Cavity.—The most important point in the *anterior* wall is the tympanic opening of the Eustachian tube, situated considerably above the floor of the tympanum, an arrangement which often produces a retention of small amounts of fluid in the cavity.

It remains to consider, now, the *posterior* wall of the tympanic cavity, in which is situated the important opening communicating with the mastoid antrum, and by that means with the mastoid cells. The *mastoid antrum* is a cavity of irregular shape, the roof of which is a continuation backward of the tegmen tympani. It is formed by a hollowing out of the basis of the pyramidal part of the temporal bone, which is joined to the mastoid portion and the upper part of the latter. This cavity may extend forward into the root of the zygomatic arch and downward into the mastoid cells. It communicates with the tympanum by means of a wide opening, the under edge of which is about on a level with the oval window. The floor of the tympanic cavity rises backward to meet this opening, in the same way as it rises anteriorly to the opening for the Eustachian tube.

Course of the Facial Nerve.—Although the *canalis facialis* has been already mentioned in connection with the inner wall of the tympanum, further attention should be given at this point to the course of the facial nerve, and the important relations it sustains to the structures in the posterior portion of the tympanum and to the mastoid cells.

The *facial canal* rises at the fundus of the internal auditory meatus, and after leaving it passes somewhat in front of and

further outward than it, between the cochlea and the semi-circular canals, above the roof of the vestibule. Upon reaching the plane of the inner wall of the tympanic cavity, it turns[1] suddenly backward at right angles to its former course, and running above the position of the oval window, curves gradually backward and downward, to escape from the tympanic cavity at the stylo-mastoid foramen in the postero-exterior surface of the petrous bone. In the anterior wall of the facial canal, *i. e.* in that surface turned towards the tympanic cavity, very near the stylo-mastoid opening, is a small foramen leading to the *canalis chordæ*, which, leaving the facial canal at an acute angle, runs upward and forward through the substance of the petrous bone to the tympanum, in the lower external corner of which it opens. (Fig. 23.)

Development of the Bony Canals in and about the Tympanic Cavity.—1. Carotid canal. The carotid canal is the simplest in structure and formation of the canals in or about the tympanum.[2] It appears about the third or fourth month of fœtal life, as a simple furrow on the inner side of the blunt point of the petrous part of the temporal bone. By the end of the fourth month a bony ridge rises out of the furrow on the tympanic side and pushes its way between the cerebral carotid and the tympanum, thus forming a bony partition between them. Another osseous ridge grows from below upward and joins this first ridge, forming with it, by the ninth fœtal month, the complete carotid canal.

2. Fallopian canal. This canal, too, appears at first as a simple broad groove in the tympanum. About the third month of fœtal life this canal begins to form by the gradual growth of thin bony lamellæ. The eminentia stapedii forms as a branch-like projection from the facial canal. The formation of the Fallopian canal is not complete until after birth. Dr. Rüdinger also describes a constant opening in that part of the facial canal over the oval window. This would seem to correspond to that one described by Dr. Zuckerkandl as the point of entrance of the stapedial artery into the tympanic cavity. The history of

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[1] *Genu canalis facialis*, at which point the canal for the great superficial petrosal nerve joins the facial canal. (Henlé.)

[2] Prof. Rüdinger, Monatsschr. f. Ohrenh., No. 5, 1873.

the development of the canaliculus chordæ, the canaliculus tympanicus and mastoideus Arnoldi, and of the bony portion of the Eustachian tube and semicanal of the tensor tympani is, in many respects, according to Rüdinger, similar to the above.

Lymphatic Cavity in the Facial Canal.—On the inner side of the facial canal, Dr. Rüdinger[1] has described an empty space lying between the nerve trunk and the periosteum. This cavity or cleft, as it would appear in a transverse microscopical section, presents a sharp definition, and appears as a constant occurrence in every individual case examined. The supposition is that this space marks an extension of the arachnoideal sac of the brain running along the facial nerve, and is similar to that which is known to accompany both the optic and the acoustic nerve; it may therefore be regarded as a lymph cavity.

Chorda Tympani Nerve.—The chorda tympani, as already indicated, is a branch of the facial nerve. After its entrance

Fig. 24.
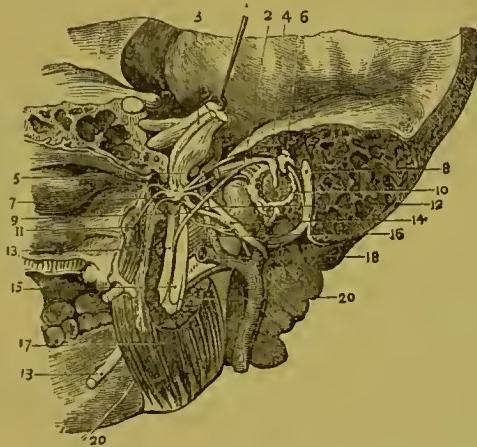
NERVES IN AND ABOUT THE TYMPANUM. (Heath.)—1. Sensory portion of fifth nerve with Gaserian ganglion. 2. Tensor tympani muscle. 3. Motor portion of fifth nerve passing beneath the ganglion. 4. Malleus. 5. Small superficial petrosal nerves of Arnold. 6. Incus. 7. Otic ganglion. 8. Facial nerve. 9. Chorda tympani. 10. Membrana tympani. 11. Tensor palati muscle. 12. Middle meningeal artery. 13, 13. Lingual nerve. 14. Auriculo-temporal nerve. 15. Inferior dental nerve. 16. Pterygoideus externus. 17. Pterygoideus internus. 18. Internal maxillary artery. 20, 20. Mylohyoid nerve.

into the tympanic cavity it becomes invested with mucous membrane, and, ascending into the cavity, follows quite closely

[1] Ueber den canalis facialis in seiner Beziehung, zum siebenten Gehirnnerven beim Erwachsenen, M. f. O., 1873, No. 6.

the posterior periphery of the membrana tympani until it reaches the height of the tendon of the tensor tympani, when it winds forward, above this tendon, between the malleus and incus, and finally escapes from the tympanic cavity at the Glaserian fissure, through the canal of Huguier. It then descends between the two pterygoid muscles, to unite with the gustatory nerve, and is finally distributed with it to the submaxillary gland; it then joins the submaxillary ganglion and terminates in the lingualis muscle, as shown by Gray. This nerve has very little sensibility according to Vulpian,[1] whose experiments have shown that the chorda tympani contains both centrifugal and centripetal fibres, the latter serving as a means of excito-motory irritation, destined to act on the sublingual gland. According to Vulpian, and Prevost of Geneva, part of the chorda tympani accompanies the lingual nerve in its peripheric distribution, furnishing branches to all the terminal filaments of the latter. This nerve has no connection whatever with the auditory nerve, and therefore no phenomena of the former can be construed into symptoms of diagnostic value respecting the nerve of hearing.

Nerves supplying the Mucous Membrane of the Tympanic Cavity. —The nerves supplying the mucous membrane of the tympanic cavity as well as that of the Eustachian tube and mastoid cells, are derived from the tympanic plexus, an anastomosis between the otic ganglion, petrosal ganglion of the glosso-pharyngeal nerve, and the carotid plexus, by means of the superior cervical ganglion of the sympathetic nerve.[2]

The *otic ganglion* is situated on the inner side of the sensory division of the inferior maxillary nerve, and sends several small branches to it. It is important to bear these relations in mind when considering certain neuralgias in and about the ear, which might otherwise prove very puzzling.

In an infirmary practice, numerous cases of earache are constantly seen, which are solely and clearly due to imperfect teeth. By means of the otic ganglion, the soft palate, the drum-head, and tensor tympani muscle, the lining membrane of the cavity

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[1] Gazette Médicale de Paris, Feb. 15, 1873.
[2] Bischoff, Microscopische Analyse der Kopfnerven, München, 1865.

of the tympanum, and the integument of the external ear are put in sympathetic relation with each other and with the nervous system.

Perhaps certain epileptiform phenomena which have been observed in connection with well-marked disease of the middle ear, as well as similar phenomena which could be seen to be connected with an obscure disease of the organ of hearing, may be explained by reflex communication through the tympanic plexus, especially through the petrous ganglion of the glosso-pharyngeal, to the brain and spinal cord.

The *tympanic nerve* or *Jacobson's nerve* is a branch from the petrosal ganglion[1] of the glosso-pharyngeal nerve; " it enters a small bony canal on the base of the petrous portion of the temporal bone, ascends to the tympanum, enters this cavity by an aperture in its floor close to the inner wall, and divides into three branches, which are contained in grooves upon the surface of the promontory."[2] This is the largest nerve branch given to the tympanic cavity, and therefore it has received its special name and consideration from most anatomists. Since, however, the tympanic nerve contains so large a number of large ganglion cells, either solitary or grouped, and thus makes numerous connections with other important ganglia and nerves, the name *tympanic plexus* is now given to what formerly was named, in its tympanic portion at least, the tympanic nerve.

Bloodvessels of the Tympanic Cavity.—The chief artery of the tympanic cavity runs along the floor of the tympanum and over the promontory. The capillaries of these vessels empty at last into the veins of the periosteum.[3]

According to Gray, the arteries supplying the tympanic cavity are as follows : The *tympanic branch* of the *inferior maxillary* which is given to the *membrana tympani*, the *stylo-mastoid* branch of the *posterior auricular*, distributed to the back part of the *tympanic cavity* and *mastoid cells*, a number of smaller branches from the *petrosal* branch of the *middle meningeal*, and branches from the ascending pharyngeal and internal carotid. The *veins* of the tympanic cavity terminate in the *middle meningeal* and *pharyngeal veins*, which form a plexus near the glenoid

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[1] Andersch.   [2] Gray.   [3] Kessel.

articulation, and then empty into the *internal jugular vein*. It is very important to bear in mind these distributions of blood-vessels, when the ear is to be leeched.

Dr. Zuckerkandl[1] has described as constant, an artery which he has termed the arteria stapedia. This artery is a branch of the stylo-mastoid artery, which enters the tympanum through an ever-present triangular opening in that part of the facial canal passing just above the fenestra ovalis. This small vessel descends through the membrana obturatoria of the stapes, either to anastomose with a branch of the artery following Jacobson's nerve, or to break up into secondary anastomoses before it reaches this point. Before the artery passes the stapes it gives off a branch to the anterior crus of the stapes and to the anterior part of the membrana stapedia which it divides in two, a second branch to the hinder crus and to the posterior part of the stapedial membrane, and a third arteriole usually from one of the lateral branches passes inward to the foot-plate of the stapes.

PHYSIOLOGY.

The function of the tensor tympani muscle is somewhat like that of the palmaris,[2] *i. e.* it is better adapted for tension than for motion. It also appears that, by exerting a slight tension on the membrana tympani, this muscle can bring about a muffling or damping effect without any visible movements in the ossicles.

In 1860, Politzer[3] showed that the tensor tympani was supplied by a branch of the motor division of the fifth nerve.

Later, Voltolini[4] performed a series of experiments which led him to the following conclusions:—

"1. Irritation (by electricity) of the trigeminus produces distinct and powerful contractions of the tensor tympani, which can be kept up for some time on the dead animal; these contractions can almost always be produced even by weak streams of electricity.

"2. The same result can be obtained by irritation of the facia-

[1] Ueber die Arteria Stapedia des Menschen, Monatsschr., f. O. No. 1, 1873.
[2] Henlé, op. cit. p. 748.   [3] Meissner's Jahresbericht, p. 583.
[4] Virchow's Archiv, Band 65, p. 467.

lis, but usually only by strong electric currents, and the irritability is generally soon lost.

"3. During this contraction of the tensor, the drum-head is drawn strongly inward by means of the manubrium, but, of course, these excursions of the drum-head vary in different animals ; in guinea-pigs they are so small as to be undistinguishable unless an indicator is attached to the membrane.

"4. During such a contraction of the tensor and the consequent tension of the membrana tympani, a simultaneous ascent of the lymph in an opened semicircular canal becomes visible in the dead animal, and when the tension is removed the fluid sinks back.

"5. In no instance, neither by excitation of the trigeminus, nor of the facial nerve, nor even by mechanical movement of the stirrup, was a simultaneous movement in the membrana tympani secundaria visible, not even by microscopic observation of a reflection, or an indicator attached to the membrane.

"6. During irritation of the trigeminus, and the consequent contraction of the tensor tympani, there ensues a contraction of the palatal muscles and an opening of the Eustachian tube, for the anterior membranous wall is drawn away from the posterior cartilaginous tubal ridge."

The fact that the tensor tympani can be put into motion by excitation of two cerebral nerves, as above stated, may, according to Voltolini, be used as an explanation of the power the muscle has of both voluntary and involuntary movement.

In one of his experiments, Voltolini observed that excitation of the facial nerve produced contractions in the tensor tympani and stapedius muscle. Such a process, says the observer, is of highest importance in the act of hearing, if, indeed, such a process occur in the living ear, which is not to be doubted ; in such an event the stapedius muscle acts as a check on the movement of the hammer by the tensor tympani.[1] The reflex movements of the tensor may be accounted for by the branch of the trigeminus which passes through the otic ganglion.

Then arises, as Voltolini suggests, the important question whether the fibre from the facial nerve, supplying the tensor, also passes through the otic ganglion, or goes directly from the facial to the muscle ; in the latter case the muscle would evi-

[1] Loc. cit., p. 479.

dently possess power of voluntary motion. Although no one has demonstrated that a branch of the facial nerve does pass directly to the tensor tympani, the muscle certainly possesses power of voluntary contraction, as held by Johannes Müller, Voltolini, and others.

Physiological Nature of certain Tympanic Bands, heretofore considered Pathological.—Dr. Victor Urbantschitsch[1] has pointed out the physiological nature of certain membranous and cord-like adhesions in the cavity of the tympanum, which have heretofore been considered pathological. As he states, Prof. Politzer was the first to express the opinion that such might be the case, and the former has verified this opinion by a series of careful and copious investigations on the cadaver of embryos, new-born children, and adults.

Dr. Urbantschitsch has frequently found, in the new-born child, membranous and cord-like connections between the inner side of the vertical shaft of the incus and the inner wall of the tympanum. This has been considered pathological by Toynbee and other authors; but Urbantschitsch has shown that these formations are remnants of an embryonic fold, running from the vertical ramus of the incus to the inner wall of the tympanum, entirely inclosing the stapes. This was seen eight times in embryos, fifty times in the new-born child, and sixteen times in fifty examinations of the tympanic cavity in the adult.

There is also an embryonal stapedial fold which sometimes leaves as residue small membranes or cords passing from the head and shafts of the stapes. But this observer does not assert that all of the connecting bands or membranes which he has described are always of a physiological nature; he believes that their occurrence, without any morbid changes in the tympanic cavity, would not justify the conclusion that a pathological process preceded their formation. Similar connections between the posterior, anterior, and exterior surface of the vertical ramus of the incus with the structures of the tympanum are shown to be normal. The first point agrees with the investigations of Lineke; the second point agrees with the statement of v. Troeltsch.

[1] Beiträg zur Entwickelungsgeschichte der Paukenhöhle. Report of Royal Academy of Sciences, Vienna, Jan. 1873.

The horizontal ramus of the incus may be joined to the external wall of the tympanum, and with the mastoid cells, by similar membranous connection. The union with the outer wall has already been shown by Zaufal to be a normal one. This was found by Urbantschitsch in eighty per cent. of all the adults examined.

The membrane so frequently found between the tendon of the tensor tympani and the antero-superior wall of the tympanum, as described by Prussak, Gruber, and Zaufal, has been observed in adults by Urbantschitsch, sometimes as a perfect membrane, and sometimes perforated in the middle or represented only by a few adhesive bands.

Hyrtl's discovery that osteophytes are regularly found in the tympanum of many of the mammals, is carried still further by Urbantschitsch, who shows that there is in the tympanum of man, a series of membranous bands containing structures similar to osteophytes which are of a physiological nature. They were found in one-third of all the adult tympana examined.

Hyrtl says that these osteophytes are formed in the tympana of animals during the early years of life; Urbantschitsch has found them in the tympanum of the new-born child sixteen times in fifty examinations.

These are usually found on the eminentia pyramidalis. They may also be found on the hinder and outer wall of the tympanum, and on the border of the round window.

They are usually in connection with a membranous or cord-like structure. Meckel has described a bony ridge between the eminentia pryamidalis and the oval window. In one case, among fifty examined, Urbantschitsch found a bony growth between the eminentia pryamidalis and the inner wall of the tympanum.

The posterior wall of the tympanum often contains a bony formation resembling a lamella. " This forms, either alone or in combination with membranes, a partition which divides the posterior portion of the tympanic cavity into a superior, larger space, and an inferior, smaller one."

Function of the Round Window and its Membrane.—In 1871 I made some investigations into the condition of the membrana secundaria, or the membrane of the round window, during the

movements of the ossicles of hearing; and the excursions per-
formed by it were measured under the microscope. During
these investigations I also noticed the effect of varying laby-
rinthine pressure upon the small bones of hearing and the
membrane of the round window.

All the observations were made upon temporal bones from
human subjects, as soon as possible after death. Of the ten
specimens thus used, eight were from males and two from
females; the ages varying from six years to forty-five years.
During the intervals between the experiments, the temporal
bones were kept in a ten per cent. solution of alcohol. To pre-
pare the bones for examination under the microscope, the Eus-
tachian tube was removed up to its bony portion, but the
membrana tympani, with the annulus tympanicus, the chain of
ossicles, and the labyrinth, were left entirely intact.

In order to obtain the best view of the fenestra rotunda, the
floor of the tympanum was removed as high as the round
window, till it and the promontorium cochleæ were fully ex-
posed. The chief difficulty experienced in thus exposing the
round window is the liability to encroach upon the posterior
semicircular canal.

To avoid this, a view of the window was first gained, by
cautiously chiselling away the posterior portion of the floor of
the tympanum. Then the entire preparation was turned for-
ward about an axis running through the porus acusticus in-
ternus and the external auditory meatus, and the bone was
chiselled away in all directions, excepting outward and upward,
till a perfect view of the round window was obtained. The
preparation was then fastened firmly in a vise, and laid so as to
be conveniently approached by a microscope, and to receive, by
means of a condenser, light from a kerosene lamp. The prepa-
ration now lay so as to expose the chain of ossicles from under-
neath, and the membrana tympani secundaria, at an angle of
about 45°. These were sprinkled lightly with powdered starch,[1]
so as to insure bright vibrating points.

Sources of Sound.—As sources of sound, four organ-pipes were
used, of respectively 50, 140, 630, 1160 vibrations per second.
The first was a reed-pipe, the three remaining ones were stopped

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[1] Lissajou's Method.

pipes. These were connected with the ear, in each case, by means of a gutta-percha tube one metre long, and one-half cm. wide, fastened to the side of the reed-pipe; but in the case of the other three, at the closed end.

The free end of the connecting gutta-percha tube was supplied with a tapering glass tube, pointed with sealing-wax, moulded to the external auditory meatus, thus procuring an air-tight communication between the organ-pipe and the membrana tympani. All unwished-for vibrations were avoided by placing the pipes upon separate tables, and in some instances they were held in the hand during the sounding of a note. This necessitated all vibrations which reached the ear to pass through the connecting gutta-percha tube.

The position of the glass tube in the external auditory meatus has great influence on the experiments. When the tube is directed downward and forward, the experiments are almost invariably successful, but in any other position they may be partially or entirely unsatisfactory.

For, in the former position, the sound-waves strike more directly against the membrana tympani and the hammer, whereas in any other position they are forced against the sides of the auditory canal, and are deflected and destroyed before they reach their destination. This seems to indicate that sound, entering the external auditory meatus, produces no easily distinguishable effect upon the ossicles of hearing and the labyrinth, by simple conduction through the bony walls of the auditory canal. It must, indeed, be forced against the membrana tympani, and through it act upon the ossicula auditus. These, in turn, act like a lever, communicating their movements to the fluid of the labyrinth and the membrane of the round window.

Upon producing a note upon a given organ-pipe connected with the ear, as already described, the chain of bones was seen to vibrate in excursions, bearing a fixed relation to each other.[1] At the same time, their motion was communicated through the labyrinth to the membrane of the round window, upon which

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[1] The movements of these bones, in connection with sound-waves, have also been observed, and their excursions measured by Politzer and Buck.

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the excursions of the shining particles maintained an almost constant relation of equality with those of the stapes.

The excursions, both upon the chain of ossicles and upon the membrane of the round window, varied in their length with the pitch of the note produced by the organ-pipe; the longer excursion corresponding to the deeper note.

By the use of a syren, which was fitted to a pipe opened at its side to accommodate the gutta-percha connecting tube, excursions synchronous with the revolutions of the disk were produced upon the chain of ossicles and the membrane of the round window. These could be counted during the early revolutions of the disk; but as they increased and the note ascended, the vibrating points became lines diminishing in length with the increasing rapidity of the revolution.

During these observations one preparation was found which did not respond to the notes of the organ-pipes as the previous ones had done. The ossicula auditus manifested some very slight vibratory motions, but the membrane of the round window showed none.

In order to explain this apparently abnormal result, and to find out whether an increased or diminished labyrinthine pressure could have produced it, the following experiments were instituted :—

Upon a perfect petrous bone, which failed to respond to the sounds produced by the already-mentioned pipes, the superior semicircular canal was opened at its summit, and to this opening one end of a small glass tube, 1 centimetre long by 5 mm. wide, was hermetically sealed. The bone thus modified was placed in water and brought under the air-pump, in order to remove any air which might have entered the labyrinth. After these arrangements the glass tube, sealed to the superior semicircular canal, was connected by a gutta-percha tube, of similar diameter, to a reservoir of water, consisting of a funnel placed in a retort-holder, and which could be elevated or depressed at will.

The pressure exercised by the water upon the labyrinth could be easily seen with the unaided eye, as the varying height of the funnel caused the column of water to press with a greater or less force upon the membrane of the round window.

With these modifications the preparation, which formerly failed to respond to the notes of the organ-pipes, was placed in connection with the sources of sound, and the chain of bones, as well as the membrane of the round window, was observed during the passage of a note to the ear.

The desired excursions now became apparent upon the hitherto abnormal specimen, and resembled those upon other preparations so long as the pressure was maintained at a certain grade; but when increased or diminished beyond a given point, the excursions ceased upon the ossicles and the membrane of the round window. *This was observed to be the case sooner during the occurrence of high than of low and powerful notes.*

The human ear, in the living state, sometimes fails to perceive high notes, while lower ones are distinctly heard.

Perhaps such phenomena may be explained by an application of the results obtained in these investigations, in which artificial labyrinthine pressure interfered with the action of the chain of ossicles and the membrane of the round window, sooner in connection with high notes than with lower ones. Pathological processes, with results of a purulent,[1] serous, or hemorrhagic[2] nature, have been observed, and their injurious effects upon the sense of hearing noted.

In such cases it may be supposed that the increased amount of pathological fluids in the labyrinth interfere with the action of the chain of bones and the membrane of the round window, just as the artificial pressure did in my experiments.

In addition to these destructive changes, which follow pathological processes in the ear, the perilymph of the labyrinth may be subject to great fluctuations in its amount, since the arachnoid sac and the labyrinth are so intimately connected, as experiments of Weber-Liel[3] and Hasse show. The latter says:[4] " All vertebrates possess a duct which originates in the vestibule; and in all animals, with the exception of the Plagiostomes,

[1] Moos, Deafness in Meningitis Cerebro-spinalis. Archives of Ophthalmol. and Otol., vol. i., No. 2, 1870.

[2] Moos's Four Cases of Gunshot Wounds of the Ear, Archives of Oph. and Otol., vol. ii. p. 343.

[3] M. f. O. August, 1870.

[4] Anatomische Studien, No. xix. p. 768.

in which it passes directly to the surface of the skull, this duct enters the cavity of the cranium and there terminates either in a closed sac at the confines of an epicerebral lymph-cavity, or opens into the same. This is the ductus endolymphaticus or the aquæductus vestibuli with the saccus endolymphaticus, the former of which, in most vertebrates, arises from the sacculus, that is, from the inferior portion of the vestibule.

" Every increased or diminished pressure of the fluid of the liquor cerebrospinalis in the subarachnoid cavity will make itself felt per continuitatem through the saccus and the ductus endolymphaticus, in the interior of the auditory apparatus, in the endolymphatic cavity and upon the terminal apparatus of the auditory nerve found therein. We may thus explain most easily the impairment of hearing for high tones in cases of increased pressure."

In concluding this account of my experiments, I would call attention to a fact of interest respecting the direction of a line described by a vibrating starch-point upon the membrane of the round window. It was observed that such a line invariably remained parallel to the plane of the membrana tympani.

An explanation may be found in ultimately discovering an unequal tension of the membrana tympani secundaria, dependent upon the manner of its insertion into its frame.

The following deductions may be drawn from the foregoing experiments :—

1. The excursions of the chain of ossicles of hearing bear a fixed relation to each other.

2. The excursions of the ossicles of hearing are communicated through the labyrinthine fluid to the membrane of the round window.

3. The excursion of the membrane of the round window generally equals that of the stapes ; but it may equal that of the membrana tympani, at the point of the manubrium mallei.

4. The pressure within the labyrinth, increased beyond certain limits, causes cessation of the action of the membrane of the round window and the chain of ossicles of hearing. This occurs sooner in connection with high notes than with the lower notes of the scale.

5. If the labyrinthine pressure is greatly diminished or totally

removed, the chain of ossicles may continue to vibrate, but they exert no influence upon the membrane of the round window.

6. The vibrations of the membrane of the round window vary from $\frac{1}{1000}$ mm. to $\frac{32}{1000}$ mm.[1]

A difference of opinion has existed respecting the part the membrane of the round window plays in the conduction of sound.

Without doubt the excursions of the ossicles of hearing are conveyed through the water of the labyrinth to the membrane of the round window, as shown by the experiments of the author, and later by the corroborative experiments of Weber-Liel.

Some authorities have thought that perhaps the membrana tympani secundaria participates *directly* on the sound waves transmitted to it by the membrana tympani through the air of the tympanum. Johannes Müller inclined to this opinion, but the experiments of Schmiedekam and Hensen seemed to show that he was incorrect in his views. Recently Weber-Liel[2] has performed a series of experiments which are not only very interesting, but tend to decide this question affirmatively.

These experiments were performed on nine fresh preparations of the ear; seven were from man, one from a calf, and one from a horse. The ears were prepared for examination in a way similar to that described on page 96.

The sources of sound were the human voice and three organ-pipes; the fundamental notes of the latter were such as gave 180, 210, and 540 vibrations per second.

The sounds from these pipes and the voice were conveyed to the prepared ears, in a manner similar to that described on p. 97.

The preparations were sprinkled with starch, illuminated, and held firmly, in the manner described at the same place.

The first results of Weber-Liel's observation were in entire harmony with those obtained by the author.

But Weber-Liel then carried his experiments further, and obtained the following results :—

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[1] All the measurements I obtained may be found recorded in the Archives of Oph. and Otol., 1872.

[2] Centralblatt f. Med. Wiss., Jan. 8, 1876.

1. If the incudo-stapedial joint is divided, and the ineus pushed somewhat aside, and then the tympanic cavity hermetieally closed by a firmly inserted pane of glass (a microscopic cover) on the artificially opened side, while the Eustachian tube is kept slightly open, then microscopic examination of the membrane of the round window through the glass cover reveals, *almost invariably*, that also under these circumstances during the sounding of the pipes and during the singing of deeper notes, the particles of starch or the reflecting points on the membrane performed excursions, which were but slightly less ($1\frac{1}{2}$: 2) than those occurring before the division of the incudo-stapedial joint; these excursions, however, were observable only on certain parts of the membrana tympani secundaria. They did not occur when the cavity of the tympanum was reopened.

On the head and rami of the stapes faint simultaneous vibrations were observed in two cases.

2. Upon slightly rarefying or condensing per tubam the air in the tympanic cavity of the preparations arranged as above, no change was produced in the width and direction of the excursions ; when the air became more condensed, the high notes first ceased to produce vibrations ; with increasing condensation, the deeper notes ceased to have effect.

3. In order to exclude the possibility of the communication of sound waves from the oval window (foot-plate of stirrup) through the labyrinth to the membrana tympani secundaria, the labyrinth was opened and the vestibule exposed from behind. After the fluid of the labyrinth had escaped, sound-waves conducted by the membrana tympani to the labyrinth, produced no visible effect on the membrane of the round window. This negative result is attributable to the loss of pressure consequent upon the escape of the labyrinth-fluid ; for, when the cochlea was sawed transversely through, a narrow glass tube placed in the transversely sawed scala tympani, and the latter, with the glass tube, filled with various heights of water, by means of which once more a certain amount of pressure was brought upon the labyrinth side of the membrane, then, when the tympanic cavity was again closed, immediately the excursions became once more visible upon sounding the organ-pipes or singing.

4. With some of the preparations, a glass tube was cemented to the temporal bone, and through this tube, by means of a rub-

ber pipe, the labyrinth being undisturbed, sound vibrations were conveyed to the bones of the head. No excursions were perceptible, neither with the tympanum opened nor closed.

These experiments seem to prove that the membrane of the round window may be set in vibration by sound-waves from the membrana tympani conveyed through the air of the tympanic cavity.

The Power of Muscular Accommodation.—According to Prof. Lucæ's experiments,[1] the ear has, in the tensor tympani and stapedius muscles, an apparatus for accommodating itself to various sounds. The first muscle aids in the accommodation for low musical tones, the latter accomplishes the same for high, unmusical sounds.

Abnormal contraction of the tensor tympani, within sufficient antagonism of the stapedius, produces a modification of perception, termed by Dr. Lucæ "low hearing;" an analogous condition of the stapedius muscle in its relation to the tensor tympani produces "high hearing."

Action of the Tensor Tympani and Stapedius Muscles.—Confirmatory observations of Drs. Mach and Kessel[2] show that the traction on the stapedius muscle drives the head of the malleus inward, and the lower part of the membrana tympani outward. The substance of these observations is in harmony with the celebrated theories of Weber.

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[2] Beiträge zur Topographie und Mechanik des Mittelohrs. Wiener Sitzungsb., 23 April, 1874.

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CHAPTER II.

EUSTACHIAN TUBE AND MASTOID PORTION.

ANATOMY.

THE Eustachian tube, though discovered by Vesalius, gets its name from Bartolommeus Eustachius,[2] who gave a more complete description of it than any of his contemporaries or predecessors. Though it is generally conceded that Vesalius was the discoverer of the tube, some authorities think that even Alcmeon[3] and Aristotle[4] knew of its existence.

The Eustachian tube is the only means of aerial communication between the pharynx and middle ear. It opens into the pharynx a little above the floor of the nose, and passes backward, upward, and outward to the cavity of the tympanum, forming an angle of 40° with the horizon, and 135° with the axis of the external auditory canal. The pharyngeal mouth of the tube is wide, but the tube narrows rapidly to the *isthmus*,

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[1] Pflüger's Archiv für Physiologie, I. Jahrgang. ; Bonn, 1869.
[2] 1500–1574.   [3] 570 B. C.   [4] 384–322 B. C.

from which point it widens again to the tympanic cavity.   It
therefore resembles, somewhat, two short and wide-based cones,
placed point to point, their junction marking the position of
the isthmus.   The pharyngeal mouth of the tube is oval in
shape, being 9 mm. high and 5 mm. wide.   At the isthmus, the
junction of the osseous with the cartilaginous part of the tube,
the diameter is 1.5 to 2 mm., and the greatest diameters of the
osseous canal vary from 4 to 4.5 mm.   The entire length of the
Eustachian tube is 35 mm., a little more than 1 inch ; the bony
portion being 11 mm., and the cartilaginous part 24 mm. long.

Bony Portion of the Eustachian Tube.—As already indicated,
the Eustachian tube is composed of a bony and a cartilaginous
portion.   The former lies entirely within the petrous bone ;[1]
the latter portion is joined to the former and is about two-thirds
of the entire tube.   The calibre of the bony portion is triangular,
the angles, however, are rounded by the mucous lining of the
tube.   Its average diameter is about 2 mm.   The outer wall of
the three composing this triangular bony tube, belongs to the
pars tympanica, the tympanic bone, the inner wall separates the
tube from the carotid canal, and the upper wall is formed inter-
nally by the septum tubæ, and the floor of the canal for the
tensor tympani, and outwardly it unites with the outer wall of
the bony tube in the petro-tympanic or Glaserian fissure.   The
posterior wall of the bony portion of the canal is somewhat
longer than the anterior wall.   Usually the bony Eustachian
tube is twice as wide as the semi-canal of the tensor tympani,
but in some instances these relations are reversed, as shown by
Rüdinger.

Cartilaginous Portion of the Eustachian Tube.—In order to
understand the true form of this part of the Eustachian tube,
one must imagine a shell of cartilage, not quite an inch long,
bent so that a section of it at right angles to its long diameter
resembles a hook or shepherd's crook.   The longer portion of
this section of cartilage will represent a section of the inner

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[1] In some cases the large wing of the sphenoid bone unites in the formation
of the osseous part of the Eustachian tube, or at least it forms with the pars
petrosa, the sulcus petro-sphenoidalis for the reception of the cartilage of the
tube.   (Rüdinger, Die Ohrtrompete, p. 2.)

wall, the shorter portion represents that of the anterior or outer wall, and the curve shows the position of the roof of the Eustachian tube. It will be seen, therefore, that this part of the tube is not a complete and round cartilaginous canal, but rather a flattened tube, the posterior wall and roof of which are made entirely of cartilage, while the anterior wall is of cartilage only in its upper part, its lower portion being *muscular*[1] and completing the tube. The upper part of the inner cartilaginous wall, as well as the roof of the tube, is fastened to the base of the skull by means of the basilar fibro-cartilage. The lower end of the inner wall is movable. That part of the cartilage of the Eustachian tube which curves forward to form the upper part of the outer or anterior wall of the tube, is widest and most movable in its middle portion; it is narrower and more firmly fixed at its two extremities, viz., above, where it is joined to the jagged bony edge of the osseous canal, and below, to the pterygoid process.

Fig. 25.
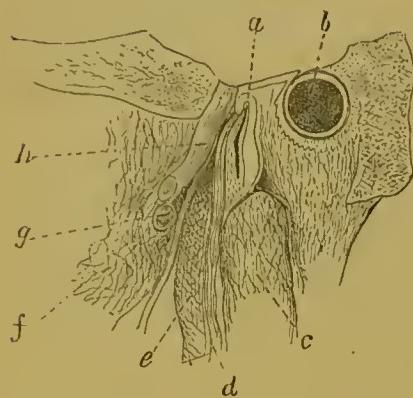
TRANSVERSE SECTION OF THE CARTILAGINOUS PART OF THE EUSTACHIAN TUBE NEAR THE FORAMEN OVALE. (Henlé.)—*b*. Section of the internal carotid. *a*. Cartilage of the tube. *h*. Third branch of the trigeminus. *g*. Middle meningeal artery. *f*, *e* Transverse section of the external and internal pterygoid muscles. *d*. M. spheno-staphylinus (tensor palati). *c*. Transverse section of the M. petrostaphylinus (levator palati).

The calibre of the tube, in the main, is not round but cleft-like, and slightly sigmoid in shape; however, that portion of the calibre lying in the curve formed by the cartilage as it turns forward, *i. e.* that part lying entirely within cartilaginous boundaries, is round and more open than the rest of the lumen of the tube, owing, probably, to the stiffness of the cartilage. This fact would always insure at least a portion of the tube's being more likely to be free from obstructions or from having its two sides stick together. To this more patulous part, Rüdinger has given the name of safety tube (Sicher-

[1] Formerly, this part of the canal was called membranous, but since muscular tissue is so intimately concerned in its formation, Rüdinger proposes to call it muscular, as being more truly descriptive.

heitsröhre), and to the cleft-like calibre of the tube below this
rounder lumen, he has given the name of "accessory cleft,"
(Hilfsspalte), "since, according to Du Bois Raymond, these
terms express most clearly their physiological importance."[1]
The posterior cartilaginous wall of the Eustachian tube projects
well into the pharynx, forming there a prominent ridge, the
anterior boundary of the fossa of Rosenmüller. Into the latter,
the Eustachian catheter is often placed in mistake for the pha-
ryngeal mouth of the Eustachian tube. When the latter is to
be catheterized, this prominent ridge, marking the termination
of the cartilage of the Eustachian tube, should be sought for
and thoroughly located with the beak of the catheter. In order
to do this it is well to allow the catheter to pass first into the
fossa of Rosenmüller, then to glide gently forward over the
aforesaid cartilaginous lip, by which act the beak can hardly
escape going into the pharyngeal mouth of the tube.

As already stated, the cartilaginous shell of the Eustachian
tube is adherent at its curve or roof to the base of the skull, by
means of the basilar fibro-cartilage; the edges of the shell, i. e.
the edges of the anterior and posterior lips of the cartilage of
the tube, are free, and from them important muscular structures
arise. The inner dilator of the tube, or the *salpingo-pharyngeus*
muscle, is one of these, and arises from the edge of the posterior
cartilaginous wall of the Eustachian tube, and passes towards
the superior constrictor of the pharynx. There is also an inti-
mate topographical[2] relation between this inner wall and the
inner surface of the levator palati (petro-staphylinus, Henlé),
which muscle, in conjunction with the salpingo-pharyngeus,
the inner dilator of the tube, brings about movements of the
cartilage. "If the levator palati be pulled upon in a fresh pre-
paration, the under end of the inner plate of cartilage will be
pushed inward and upward, by which means, the pharyngeal
mouth of the Eustachian tube will be considerably widened."[3]
Since, then, the conjoined action of these two muscles, the
levator palati and the salpingo-pharyngeus, together with the
dilatator tubæ or tensor palati, yet to be described, brings about

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[1] Rüdinger, Die Ohrtrompete, p. 7.

[2] This muscle sends a few fibres to the posterior cartilaginous wall of the
Eustachian tube near the junction of the cartilage with the bony portion of
the tube.

[3] Rüdinger, Die Ohrtrompete, p. 4.

these changes in the pharyngeal mouth of the Eustachian tube, it can easily be seen how the act of swallowing, which brings them into action, opens the tube and ventilates the middle ear.

Fig. 26.
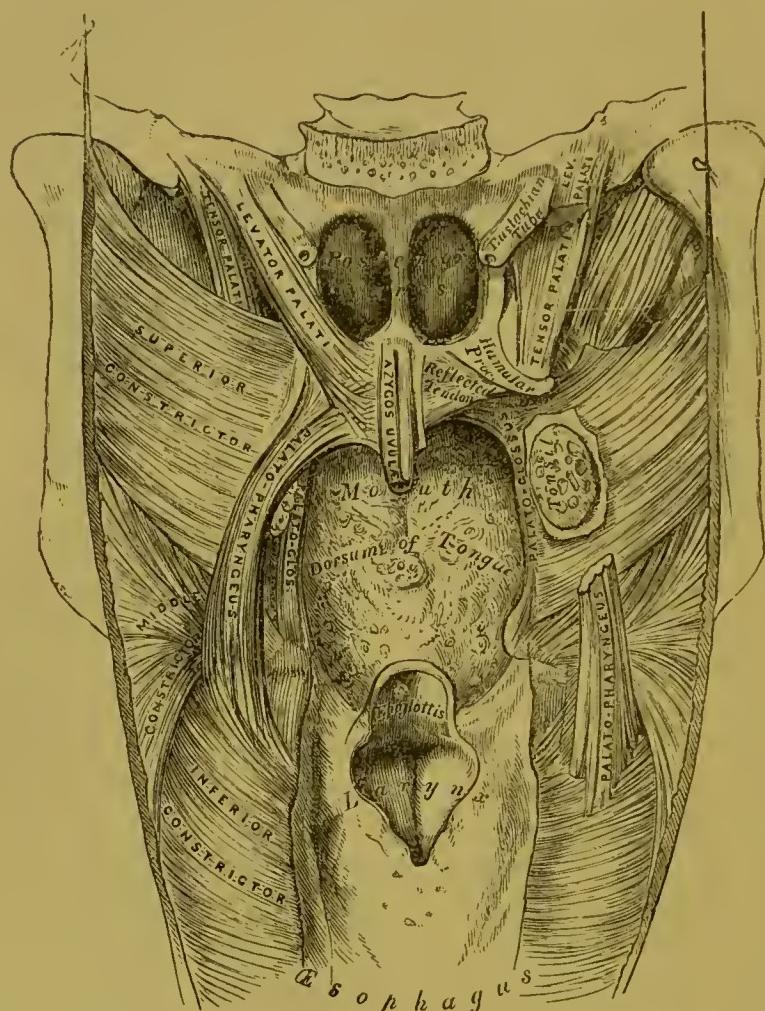
PALATAL MUSCLES VIEWED FROM BEHIND. (Gray.)—The Eustachian tube is shown here, in its regional relations to the palatal muscles, but not in its true anatomical shape.

Tensor Palati Muscle.—The most important of all the muscles of the Eustachian tube is the tensor palati.[1] This muscle arises by a flat tendon from the posterior edge of the hard palate, in intimate connection with the tendon of its fellow of the opposite side, and, gradually narrowing into the tendon which passes

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[1] This muscle has received various names: Tensor veli; Tensor veli palatini; Dilatator tubæ (Rüdinger); Spheno-salpingo Staphylinus, etc.

around the pterygoid hook, spreads out again from this point into a fan-shaped muscular layer, the free broad edge of which is inserted into almost the entire length of the anterior lip of the cartilage of the Eustachian tube.

Respecting the much-disputed origin of the tensor veli, it may be said that, according to the investigations of Dr. Urbant-schitsch,[1] there are individual variations in the origin of this muscle from the membranous part of the Eustachian canal. In some cases such an origin is wanting.

Hence has arisen the great difference of opinion between many noted investigators of the anatomy and physiology of this tube. A very important variation also occurs in the connection between the tensor tympani and tensor veli, for sometimes such a connection is not to be found, while in other cases it undoubtedly exists. In one instance it was found that the spindle-shaped tendon of the tensor tympani passed entirely into the middle belly of the tensor veli muscle. These facts are in harmony with the well-known investigations of Weber-Liel.

By the contractions of this muscle the anterior wall of the cartilage of the tube is pulled outward and downward, and thereby the calibre of the canal is widened.

According to the investigations of Rüdinger,[2] it is shown that there is a direct connection between the tensor palati (Dilatator Tubæ) and the tensor tympani muscle. Not only do the tendinous fibres, but also the muscular fibres, of the one pass over into those of the other, at the upper part of the Eustachian tube. This connection is of the greatest importance when considering the cause and treatment of certain forms of hardness of hearing due most probably to a kind of paresis in the tensor veli.

The Inner Pterygoid Muscle.—This muscle is considered by Weber-Liel as specially belonging to the muscles of the Eustachian tube.[3] According to his observations some of the upper, shorter, and hinder fibres of this muscle are inserted into the fascia of the floor of the tube throughout its length, and are

[1] Zur Anatomie der Tuba Eustachii des Menschen. Victor Urbantschitsh. Med. Jahrbuch, 1 Heft, 1875.

[2] Op. cit., p. 6.

[3] Progressive Schwerhörigkeit. Berlin, 1870, p. 68–71.

then lost in the fibrous covering of the petrous bone. Its function is that of a tensor of the fascia of the Eustachian tube.

The Ligamenta Salpingo-pharyngea. — Dr. Zuckerkandl[1] has described a constant and peculiar anatomical connection between the Eustachian tube and the constrictors of the pharynx, under the name of the ligamenta salpingo-pharyngea. His statement is that upon laying bare the posterior wall of the pharynx and dissecting off the mucous membrane, along the periphery of the pharyngeal opening of the Eustachian tube and adjacent parts, there will be found three, four, or five, perhaps more, tendinous, rarely elastic cords, attached to the pharyngeal end of the hooked cartilage of the tube, and to the outer wall of the same, which in their fullest development are likened to the tendinous cords of the valves of the heart. This anatomical arrangement, it is said, produces a free opening of the Eustachian tube at each contraction of the superior and middle constrictor of the pharynx.

The same observer has described a salpingo-pharyngeal recess below the faucial mouth of the Eustachian tube.[2]

Mucous Membrane of the Eustachian Tube. — The mucous membrane of the Eustachian tube is a continuation of that of the pharynx. It is supplied with ciliated epithelium, the cilia of which move in a direction from the tympanic cavity towards the pharynx, thereby favoring the passage of fluids from the cavity of the drum and tube into the throat.

The Eustachian tube is very rich in glands at certain places; although the upper concave portion of the cartilaginous roof of the canal is entirely free from glands, the sides of the tube, in the pharyngeal portion, are richly supplied with " acinous mucous glands," emptying into the folds of mucous membrane, as shown by Rüdinger. These mucous glands do not differ from those of the œsophagus and pharynx. In the upper portions of the tube, towards the tympanic cavity, all glands become sparse.

In addition to the glands just named, Gerlach[3] has shown the

[1] Zur Anatomie und Physiologie der Tuba Eustachiana. M. f. O., 1873, No. 12.

[2] Monatsschr. f. Ohrenh., No. 2, 1875.

[3] Zur Morphologie der Tuba Eustachii. Sitzungsberichte d. Erlanger Physicalisch-Med. Soc. Abstract by Von Troeltsch, A. f. O., vol. x. p. 53, 1875.

mucous lining of the cartilaginous portion of the tube is richly supplied with follicular glands, which are most numerous at its middle part. Placed still deeper in the submucous connective tissue, are numerous acinous glands. The follicles of the tubal mucous membrane are about half as large as those of the pharynx, but take in the entire depth of the mucous membrane.

Tonsilla Pharyngea.—According to the investigations of Santorini[1] and Luschka,[2] it is shown that the lining structures of the roof, and to a great extent the hinder wall of the nasal part of the pharynx, are composed of a tissue so strikingly like the substance of the tonsils that it has been named the "pharyngeal tonsil."

Luschka states that this spongy tonsillar substance, of a maximum thickness of 7 mm., which he has never failed to find, extends from the posterior boundary of the roof of the nasal cavity to the edge of the foramen magnum of the occipital bone, where it either assumes a more or less uneven surface, or, breaking up into separate sebaceous glands, is gradually lost in the posterior wall of the pharynx. The same kind of structure forms the chief constituent of the recessus pharyngeus, and extends in a thinner layer over the ridge of the pharyngeal mouth of the Eustachian tube.

Differences in Size and Shape of Mouth of Eustachian Tube.— Dr. Urbantschitsch,[3] a writer distinguished for conscientious research, has described some great variations in the shape and size of the pharyngeal mouth of the Eustachian tube. These variations occur not only in those of the same age, but also in the same individual. The variation in form of the cartilaginous part of the tube is observed to occur in both the posterior and anterior wall. The former may terminate in a sharp point, or it may be very blunt and rounded at the lower and posterior end; it may also be corrugated on the surface towards the lumen of the pharynx, or curled decidedly upward and forward

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[1] Parma, 1775.

[2] Der Schlundkopf des Menschen. Tübingen, 1868, p. 20–27.

[3] Anatomische Bemerkungen über die Gestalt und Lage des Ostium pharyngeum tubæ beim Menschen. A. f. O., vol. x. pp. 1–7, 1875.

towards the so-called floor of the tube. Another curious devia-
tion found in the posterior wall of the tube is a bifurcation, the
hinder limb pointing backwards, the anterior curling forwards.
The various deviations in shape, position, and direction of the
walls of the tube, described by Dr. Urbantschitsch, apply only
to the mouth, and not to the cartilage in its upper parts. They
may, in many cases, cause a widening or a narrowing of the
mouth without, of course, producing changes further up the
calibre of the tube.

According to the same authority, the direction of the pharyn-
geal mouth of the tube is generally oblique from above and in
front, backward and downward ; in exceptional cases the axis
of the mouth of the tube may run vertically or even horizon-
tally.

Bloodvessels and Nerves of the Eustachian Tube.—The arteries
supplying the Eustachian tube are the *pharyngeal* from the
external carotid, the *middle meningeal branch* of the internal
maxillary, and various small branches of the *internal carotid*.

The nerves are distributed as follows: The tensor palati, or
the dilatator tubæ muscle, is supplied by a branch from the
otic ganglion, and also by a motor branch from the internal
pterygoid nerve. The levator palati muscle is supplied by the
facial nerve through its connection with the vidian and petro-
sal nerves as well as by a branch from the vagus. The inner
dilator of the tube, the salpingo-pharyngeus, is supplied by the
glosso-pharyngeal nerve. The inner pterygoid muscle is sup-
plied by the inferior maxillary nerve. The mucous membrane
of the tube is supplied by branches of the glosso-pharyngeal
nerve, which also supplies the mucous membrane of the tym-
panic cavity.

The Mastoid Portion and its Cells.—The mastoid portion is
that highly important part of the middle ear situate behind
and partly below the cavity of the tympanum. It corresponds
to the protuberance behind the auricle. This hollow portion is
developed partly from the squamous portion, but chiefly from
the petrous part of the temporal bone. As is well known, the
temporal bone is formed from three distinct pieces, the squama,
the annulus tympanicus, and the petrous pyramid. The squama

is divided into two parts, viz., the vertical and the horizontal portions. The horizontal portion is subdivided into an inner and an outer lamella, the latter of which forms part of the air-cavities of the mastoid portion. This portion of the temporal bone has a distinct existence by the fifth fœtal month. The mastoid portion is really a continuation of the petrous part of the temporal bone, backward and downward. In the new-born child it extends half an inch beyond the hindmost boundary of the squama, and forms a three-sided pyramid, the point of which is behind, the base of which is in front towards the tympanum, and the sharp free edge of which is directed downward. The outer surface of this pyramid corresponds of course to the outer wall of the mastoid portion, the inner surface divides the mastoid cavity from that of the cranium, and the upper surface is in the same plane with, and is a continuation backward of, the upper surface of the petrous portion of the bone. All of these features are most clearly seen in the new-born child.

The *upper surface* of the mastoid portion unites with the postero-external edge of the roof of the tympanum. This is marked by a furrow until immediately after birth, when it usually becomes invisible.

The *outer surface* shows a deficiency in the child a few months old, at its upper and anterior edge, in the shape of a fissure named the mastoid-squamous. Sometimes at this early age, the fissure is not at all marked, its place being represented by a series of irregular openings varying from two to three mm. in diameter, as though union between the squama and the outer mastoid wall were already far advanced.

The *inner surface* is quite concave, and over it runs a furrow, which at last is fully developed into the sigmoid sinus.

The *mastoid foramina* are found near that point where the upper and under edges of the mastoid portion meet. In some cases the foramina are not complete until the occipital bone joins the mastoid edges. These openings are for the passage of arteries to the dura mater, and for small veins which connect the transverse or lateral sinus with the veins of the scalp.

Mastoid Cells.—Within the mastoid portion are found the delicate mastoid cells. These are a series of bony air chambers of variable size, communicating with each other by means of

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foramina in their thin walls. They communicate with the tympanic cavity by means of the mastoid antrum, and are lined by a continuation of the same mucous membrane lining the Eustachian tube and tympanic cavity. The quantity and development of these cells vary, not only in different individuals, but in the same individual, on the two sides. It is of the highest importance to understand their general distribution in the adult bone, in order to diagnose and treat inflammatory processes arising there, or which have spread to that part from the tympanic cavity.

Fig. 27.
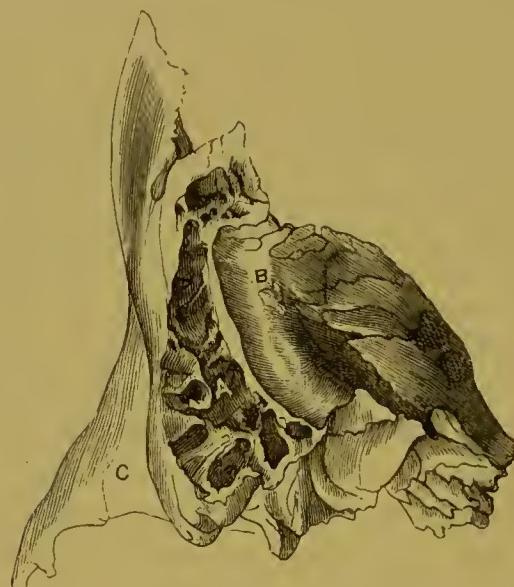
MASTOID PORTION OF THE LEFT TEMPORAL BONE LAID OPEN AND VIEWED FROM BEHIND.— A. Mastoid cells extending from the mastoid process below, upward and inward, over the lateral sinus B. C. The zygoma.

In the mastoid portion of the child it is found that the septum dividing the mastoid cavity from the sigmoid sinus is very *thick*, and hence inflammation is not likely to pass from the former to the latter, as it is in adults, in whom this septum is always thin. Hence, in very young children, meningitis very rarely, if ever, occurs from inflammation of the mastoid cavity, from which inflammation tends to pass outward rather than inward, not only because the dividing septum between it and the sigmoid sinus is thick, but because, as already stated, the outer wall of the mastoid portion is imperfect in early childhood. This is the reverse of what we find in the adult, so that

in the latter, everything favors a passage of disease inward towards the brain, while in the child, the conditions are in favor of a passage of disease outward.

The lower pointed part of the mastoid portion is known as the *mastoid process ;* to it the sterno-cleido-mastoid muscle is attached.   The development of the mastoid process is greater in the strong and muscular, while it is less developed in the weak and in children.   The mastoid portion is also subject to differences of development in different races, being small and solid in negroes, while in Mongolians it is found much more highly developed than in Caucasians, as shown by Welker.

By the eighth month of foetal life the mastoid cells are very distinctly seen as depressions in the bone of the mastoid portion. These cells are not developed first at that part of the foetal temporal bone which, at a later period, corresponds to the mastoid process, but from the upper and hinder parts of the mastoid antrum, *i. e.* from above downward, as demonstrated by Schwartze and Eysell.[1]

In the first year after birth the mastoid cavity loses its pyramidal shape by assuming a more ovoid form, and the mastoid cells are formed gradually.   Those which are included in the upper and outer portion of the mastoid portion where it joins the squama, are the most highly developed at this time, and lined with mucous membrane, while the mastoid process as yet contains no air cells.   From this time on, the external differences of this part of the temporal bone are much less than the differences in development of the air-cells within, for the latter are subject to the greatest variations in number and distribution, as can readily be seen in the skulls of adults.

The mastoid antrum, which is a connecting air chamber between the tympanic cavity and the air-cells of the mastoid portion, is of a triangular shape.   Its position is somewhat above, in front of, and further inward than, the rest of the mastoid cells.   Its walls, with the exception of part of its outer wall, are formed by the petrous part of the temporal bone, and communicate by numerous perforations with the mastoid cells, with which it is surrounded on all sides excepting in front and on the inner side. Anteriorly it has a wide opening into the tympanic cavity, and

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[1] Archiv f. Ohrenh., Band i., 1873.

on its inner side it is bounded by that part of the petrous bone covering in the horizontal semicircular canal.

It is stated in a valuable paper by Schwartze and Eysell[1] that the general shape of the mastoid cells is that of a hollow pyramid, and that their axes run like the radii of a hollow sphere, towards their centre, viz., the mastoid antrum.

The air-containing cavities fill the entire mastoid portion of the temporal bone, and in most cases they spread downward and outward to the very point of the mastoid process.

Limits of the Mastoid Cells.—The mastoid cells extend as far backward as the Emissarium mastoideum, where they are in close contact with the outer side of the groove for the mastoid sinus, and they are found as far forward as the external auditory canal. Mastoid cells are also found continuous with those which reach as far forward and upward as the petro-squamous suture, above that point where the outer table of the mastoid portion is nearest the inner table, that is, the outer wall of the sigmoid groove.

In a temporal bone shown in Fig. 27, in which the section of the mastoid portion has been made in the plane of the posterior surface of the petrous portion, and carried through the mastoid where the inner and outer tables nearly meet, characteristic air-cells are seen lying above this point in a tent-like space half an inch high, the apex of which points into the cranial cavity, and the floor of which is in the same plane as the upper surface of the petrous portion. The outer side of this tent-shaped cavity shows on section that it is continuous with and a part of the outer wall of the mastoid portion, which has grown inward, away from the squama.

The lowest limit of the mastoid cells is the tip of the mastoid process. Those cells which are developed from the petrous part of the bone are the largest; those which arise from the squama and lie over the external auditory canal are the smallest.

PHYSIOLOGY.

The Amount of constant Patulence of the Normal Eustachian Tube.—Some investigators and writers, among whom are Lucæ and Schwartze, have thought that every act of breathing is con-

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[1] Archiv f. Ohrenheilk., Band i. pp. 168–169, 1873.

veyed to the drum-cavity by a normal tube, and they have declared that this can be shown not only by the oscillations of the manometric column placed in the external auditory canal, but also by a direct viewing of the motion of the drum-head at each respiration.

Politzer, on the contrary, denies this, believing that the tube is opened only at swallowing, and the facts are in his favor.

Mach and Kessel think the movements of the drum-head observed by Lucæ and Schwartze are due to a to-and-fro motion of the column of mucus, in the capillary safety tube, produced by rarefaction and condensation of the air at the faucial mouth of the Eustachian tube.

During regular respiration through the nose the relation of the parts about the faucial mouth of the Eustachian tube does not materially change. The pharyngeal opening of the tube either remains at rest or opens and closes slightly with succeeding inspiration and expiration, after a few moments coming again to rest.

On pronouncing the vowels, particularly *a*, *e*, and *i*, the mouth of the Eustachian tube opens downward and forms an oblique triangle on the lateral wall of the pharynx.[1]

According to a subsequent paper by Zaufal,[2] Bidder[3] was the first to examine the normal relations of the parts in the nasopharyngeal space. His investigations were succeeded by those of Schuh[4] and Voltolini,[5] the latter being the first, however, to view the tubal ridge through the intact nose. Subsequently observations of these parts were made by Michel in 1873, and by Zaufal in 1875. Dr. Zaufal examined the movements of the tubal opening by means of long funnels armed with mirrors, introduced into the nares and passed back into the nasopharynx.

It is now generally conceded, through the labors of Rüdinger and others, that there is a small part of the normal Eustachian tube, the so-called safety tube, in its upper part, under the cartilaginous hook, always wide enough open to allow a recoil of air to occur from the drum-cavity, if the drum-head is suddenly driven in, as in explosions, and also to permit a slow equaliza-

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[1] Die normalen Bewegungen der Rachenmündung der Eustachischen Röhre. Prof. Zaufal, Archiv f. Ohrenh., Band ix. 1875, pp. 133 and 228.

[2] A. f. Ohrenh., vol. x. p. 19, 1875.   [3] Dorpat, 1838.

[4] Wiener Med. Wochenschr., No. 3, 1858.   [5] 1861.

tion of pressure in the tympanic cavity, from the pharynx, independently of the act of swallowing. But this "canal of safety" is not wide enough to allow constant ventilation of the drum-cavity to go on. Therefore, to insure ventilation of the tympanum, the normal tube is opened at every act of swallowing.

Prof. Moos,[1] after a careful study of the Eustachian tube, conducted chiefly by transverse sections of the frozen preparation, concludes that the tube when in a state of rest is closed at a point just behind the funnel-shaped end of the faucial opening, and that the closure extends over about two-fifths of the length of the canal. On the lower surface or floor of the tube the closure is effected by the longitudinal folds of mucous membrane which, as seen in cross-section, form a considerable prominence, literally a valve, the size of which is subject to individual variations. On the opposite surface of the canal, under the cartilage hook or roof, there is another prominence of mucous membrane, heretofore overlooked. These two prominences or folds of mucous membrane, judging from analogues in animals, seem to facilitate, by their rapid and easy unrolling, the patescence of the tube.

The islands of cartilage described by Zuckerkandl,[2] and hinted at by Rüdinger,[3] are regarded as fibro-cartilage, having physiologically the function of sesamoid bones, in the mechanism of the tube, by their connection with the submucous tissue, the fascia or ligamenta salpingo-pharyngea and the tendon of the tensor veli. In the horse the inner belly of the abductor tubæ is inserted into such a cartilaginous disk. That the Eustachian tube is practically closed, except at swallowing, is further proven by observations on themselves by Poorten,[4] Rüdinger,[5] and Yule, in all of whom, when the tube was either voluntarily opened as in Yule, or involuntarily opened as in Rüdinger and Poorten, the voice was heard abnormally loudly and painfully. The same is proven by the observations of W. Flemming, of Pragne.[6]

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[1] Beiträge zur normalen und pathologischen Anatomie und zur Pysiologie der Eustachischen Röhre, Wiesbaden, 1874. Blake's Report, 1875. American Otological Society.

[2] Centralblatt, 638, 1874.   [3] Op. cit., p. 3.

[4] Monatsschr. f. Ohrenheilk., No. 2, 1874.   [5] Ibid., No. 9, 1872.

[6] Monatsschr. f. O., No. 6, 1875.

Mr. Yule[1] has given an account of the muscular process seen to occur in his own throat during the voluntary act of opening the Eustachian tube, a power which he seems to possess.   When he makes the contractions for opening the tube, it is noted: " First, that the velum palati does not change either its position or its shape, in fact, that it remains unmoved ; and further, that it does not become tense, but hangs as soft and flaccid to the touch as at ordinary times of rest.   Secondly, that the only parts that do move are the two posterior pillars of the pharynx ; and their motion is ample and decided, and altogether unmistakable.   They both move inwards simultaneously towards the middle line, moving from their old position from one-half to three-fourths of an inch.   This action is not spasmodic, but perfectly steady, and can be sustained for some considerable time at will, the pillars maintaining their new position all the while."   Mr. Yule is quite satisfied and certain that during this period the Eustachian tube is open, and he concludes that from the flaccid condition of the velum, and also from the fact of its position and form remaining unaltered, the tensor and levator palati can have no participation in the opening of the tube, and that the muscles most evidently concerned are the palato-pharyngei.

Mr. James Hinton[2] taught that, since the salpingo-pharyngeus is united at its lower attachment with the palato-pharyngeus, and as this muscle during swallowing is drawn inwards, the salpingo-pharyngeus is drawn inwards also, and so draws the projecting cartilaginous lobe of the tube, to which it is attached superiorly, away from the opposite wall.   Therefore, the new direction given to the salpingo-pharyngeus by the movement inwards of the pillars of the fauces, is the cause of the opening of the tube. This seems to give but a partial explanation of the mode by which opening of the Eustachian tube is accomplished.   In the process, as thus explained, it would seem that the tensor palati and the anterior wall of the tube are supposed to remain fixed, the movement being confined to the muscle attached to and operating upon the posterior wall.   In swallowing, however,

[1] On Opening and Closing the Eustachian Tube.   C. I. P. Yule.   Journal of Anat. and Physiol., viii. 1873.

[2] Questions of Aural Surgery, p. 101.   London, 1874.

the velum palati is thrown into motion, and the anterior wall of the Eustachian tube is thereby drawn away from the posterior wall. At the same time, doubtless, the muscles acting upon the posterior wall of the tube are forced into contraction, and help to draw the two walls apart.

Prof. Rüdinger[1] agrees with Rebsamen that the opening of the Eustachian tube is brought about by the action of several muscles. The former supposed that the three muscles—the dilator of the tube or tensor veli, the levator veli, and the salpingo-pharyngeus—act simultaneously; by the action of the first, the cartilage hook is fixed and drawn outward; by the action of the other two the posterior wall is drawn inward and upward, the result being a patulence of the Eustachian tube. When the muscles relax, the natural elasticity of the cartilage causes it to resume its original position, and the tube becomes narrower.

Prof. Moos coincides with the view respecting the action of the tensor veli upon the anterior hook of the tubal cartilage, but rejects the idea that the levator veli assists in widening the tube.

By direct inspection of the pharyngeal end of the Eustachian tube, Dr. Michel[2] has observed that, at the act of swallowing, the velum palati rises and pushes a fold of mucous membrane into the tubal opening between the tubal ridge and the outer edge of the posterior nostril. At the termination of the act of deglutition the velum falls back to its original position and the mouth of the tube is freed from the above-named fold.

These observations of Dr. Michel have been confirmed by subsequent study of the faucial end of the Eustachian tubes in a young man who had lost by necrosis all the osseous contents of the nasal cavities and the bony roof of the nose.[3] In this case the entire nasal cavity and the nasopharyngeal space were exposed to view, and the cavity from one tubal mouth to the other, with

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[1] Die Ohrtrompete, Munich, 1870, p. 6.

[2] Das Verhältniss der Tubenmündung zum Gaumensegel am Lebenden betrachtet durch die Nase. Berlin. Klin. Wochenschr., 1873, 34.

[3] Neue Beobachtungen über das Verhalten der Rachenmündung der Tuba und über die Thätigkeit der Musculatur des Schlundkopfes. Berlin Klin. Wochenschr., No. 41, 1875. See abstract by Dr. Zaufal, Archiv f. O., B. xi. pp. 60-63.

the insertion of the velum palati, could be seen at a glance.   The observations already made by Dr. Michel were thus supple-

Fig. 28.
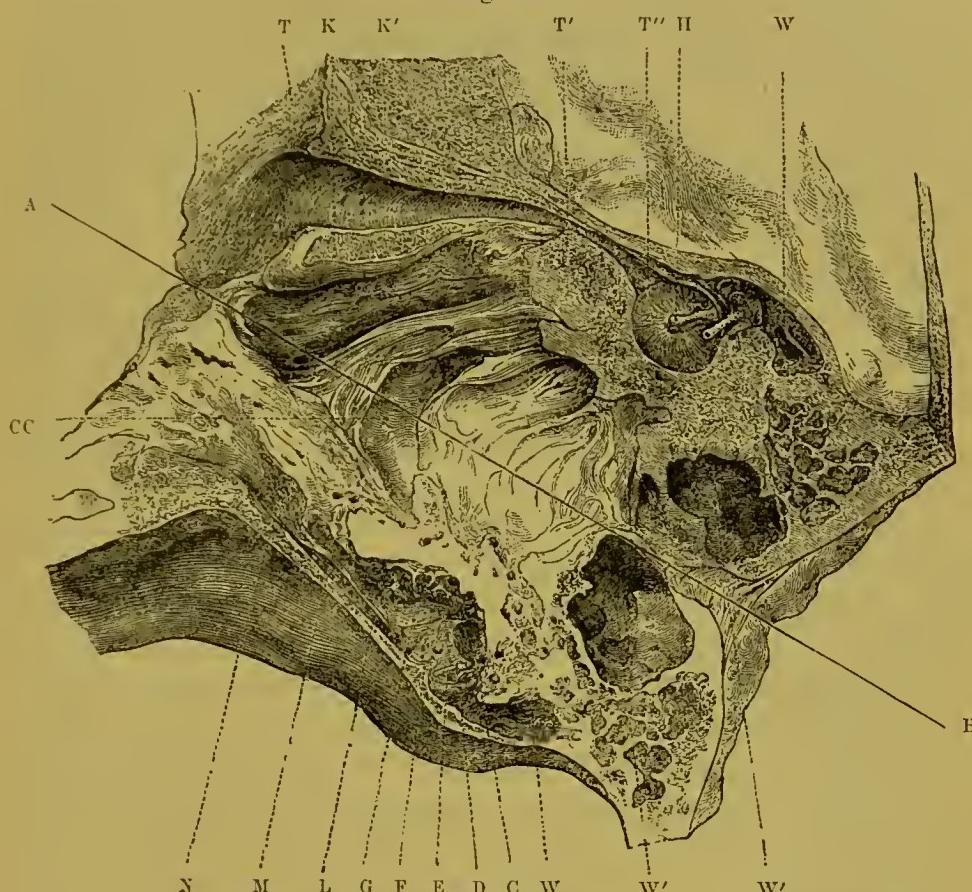
VIEW OF THE ENTIRE RIGHT MIDDLE EAR, LAID OPEN BY AN INCISION FROM ABOVE DOWNWARD, THROUGH THE CENTRE OF THE CAVITY, PARALLEL TO THE LONG AXIS.   (Gruber.) —Above the line A B, the outer half; below the line, the inner half.—T, T', T''. Eustachian tube. T'. The isthmus.   T''. The tympanic opening.   K, K'. Section of the cartilage; between these points the groove of the so-called membranous part of the tube is seen, below which the muscles of the tube are seen in section.   H. The manubrium of the malleus, with a remnant of the tendon of the tensor tympani.   Behind the manubrium may be seen the descending process of the incus; above, the articulation of the malleus and the incus.   Between the manubrium of the malleus and the shaft of the incus may be seen the chorda tympani running from behind and below, upward and forward, which also marks the edge of the folds of the membrana tympani.   W. Entrance to the mastoid cells.   W'. Large cavity in mastoid cells.

The inner half; below the line A B.—CC. Part of the petrous portion of the carotid canal (opened).   N, M. Eustachian tube.   L. Canal of the tensor tympani muscle.   F. Rostrum cochleare with part of the tendon of the tensor tympani.   G. Promontory on the inner wall of the tympanic cavity; on the posterior boundary the niche of the round window.   E. Stapes.   D. Transverse part of the Fallopian canal.   C. Eminentia pyramidalis with the tendon of the stapedius muscle still attached to the head of the stapes.   W. Entrance to the mastoid cells.   W'. Mastoid cells.

mented by watching the act of swallowing in this young man. It was found that during this act, two long vertical ridges form

on the posterior pharyngeal wall behind the lower end of the tubal prominence. These produce an upward movement and project from 1 to 1¼ cm. above the surface of the velum, but leave a space about 1 cm. broad between them. In singing, instead of such ridges, moderately thick folds are formed. From the formation of these ridges Dr. Michel is led to suppose that the floor of the tube is pushed upward by the combined action of the levator palati and the pterygo-pharyngeus, the latter by its contraction and consequent thickening pushing upward the former muscle.

The tendency in swallowing, therefore, would seem to be to force the floor of the Eustachian tube upward and its two walls apart.

Conjoint Physiology of the Eustachian Tube, Tympanic Cavity, and the Mastoid Cells.—According to the carefully conducted experiments of Mach and Kessel[1] on the functions of the tympanic cavity and the Eustachian tube, it is shown that sound-waves will produce the greatest effect when, in the middle ear, the following three conditions are maintained, viz. :—

1. The Eustachian tube must, as a rule, remain closed.

2. It must, however, be opened occasionally for purposes of ventilation.

3. The tympanum should be in connection with large irregular cavities.

These conclusions are based on the following observations and facts :—

The length of most of the audible sound-waves is so large that the entire head of the hearer is, as it were, submerged in the wave of sound, and in the case of deeper sounds, all of the superficial parts are subjected to the same variations in pressure. If, then, the membrana tympani were exposed equally on both sides to the waves of sound, it could not be set into perceptible vibrations on account of this simultaneous and equal pressure on both its surfaces.

Therefore, these observers conclude that "the waves of sound

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[1] Die Function der Trommelhöhle und der Tuba Eustachii. Sitzungsberichte der k. k. Academie d. Wissench., 1872. See also Archiv f. Ohrenh. N. F., Band ii. p. 116–121.

will produce the best effects upon the membrana tympani when it is unexposed on one side to the sound-waves, *i. e.*, when the Eustachian tube is closed."

On the other hand, it must be remembered that a difference in the atmospheric pressure on both sides of the membrana tympani is a serious interference with the mobility of the membrane. Therefore, the Eustachian tube must be opened now and then in order to restore the equilibrium in the pressure of the air on each side of the membrane, which may have been interfered with by various physical causes.

The capacity of the tympanum must not sink below a certain limit if variations in pressure of a given amount are to produce vibrations of the membrana tympani of a corresponding amount; for if the capacity of the tympanum is small, then very slight excursions of the membrana tympani will produce considerable expansive power of the inclosed air, which will operate against further increase in the vibrations.

This is a very important circumstance in the consideration of the excursions produced by deep tones. In order that the latter may be received, the tympanum must have a certain depth and a generous capacity. Therefore the tympanum is in connection with the cavities of the mastoid process, and those of other portions of bone. A larger tympanum with perfectly regular outline and form would be impracticable from its great resonance. Therefore, the irregular, spongy, bony cavities, with which the ear is connected, appear to be of the greatest advantage.

SECTION III.

INTERNAL EAR.

CHAPTER I.

LABYRINTH AND AUDITORY NERVE.

ANATOMY.

THE internal ear, sometimes called the labyrinth, is composed of a bony portion or case, and a membranous portion contained in the latter.

The bony portion of the internal ear consists of the vestibule, the central portion, with which the cochlea is connected anteriorly, and the semicircular canals posteriorly.

Fig. 29.

EXTERNAL VIEW OF A CAST OF THE LEFT LABYRINTH. (Henlé.)— *f.* Fenestra cochleæ or round window. *a.* Fenestra vestibuli, or oval window. *b.* Ampulla of superior semicircular canal. *e.* Ampulla of posterior semicircular canal. *d.* Common shaft of union of these two canals. *c.* Ampulla of the horizontal semicircular canal. *g.* Tractus spiralis foraminosus.

The Vestibule.—The vestibule is a small cavity situate just beyond the inner wall of the tympanum. This wall is common to both cavities, and in it is the oval window, into which fits the foot-plate of the small stirrup bone. A section of the vestibule parallel to its tympanic wall is round or elliptic, but a section at right angles to this, and running parallel to the floor of the tympanum, is in general of a pear shape, the point of which is directed forwards. This of course indicates that there is a general tendency on the part of the four walls of the vestibule to unite anteriorly near the cochlea. The average distance of the outer from the inner wall of the vestibule, is

from 3 to 4 mm.; its long diameter, running between its ante-
rior and posterior limits, is about 5 mm., as given by Henlé.

On the inner walls are found two depressions separated by a
narrow, sharp ridge; the anterior depression is the *recessus
sphæricus* for the reception of the *sacculus rotundus*, and the
posterior depression is the *recessus ellipticus* in which lies the
utriculus. The ridge between these grooves is the *crista vestibuli*.

Fig. 30.
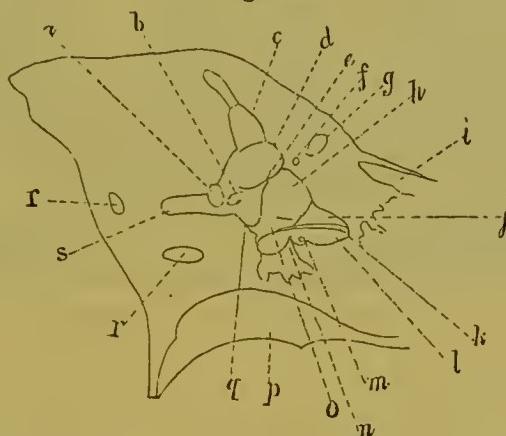
SECTION OF THE PYRAMIDAL PART OF THE RIGHT TEMPORAL BONE, THROUGH THE VESTI-
BULUM PARALLEL WITH THE OUTER WALL OF LATTER ; VIEW OF INNER WALL. (Henlé.)—*a.*
Common opening of the superior and posterior semicircular canals. *b.* Sinus sulciformis. *c.*
Ampullar end of anterior vertical or superior semicircular canal. *d.* Recessus ellipticus. *e.* Crista
vestibuli. *f.* Section of the small canal which conveys the branch of the vestibular nerve to the
pyramid of the vestibule. *g.* Section of the facial canal. *h.* Recessus sphæricus. *i.* Canal of
the tensor tympani. *j.* Scala vestibuli. *k.* Lamina spiralis. *l.* Scala tympani. *m.* Inner
opening of the aquæductus cochleæ. *n.* Crista semilunaris. *o.* Recessus cochleæ. *p.* Fossa
jugularis. *q.* Ampullar opening of the posterior vertical, or posterior semicircular canal. *r, r.*
Sections of this canal. *s.* Posterior opening of the horizontal semicircular canal.

The latter finally terminates above the oval window, on the
outer wall, in a sharp point named the pyramis vestibuli. Below,
the crista vestibuli divides into two branches, the one skirting
along the lower edge of the *recessus sphæricus,* and the other
running backwards towards the ampulla of the posterior semi-
circular canal. These branches inclose the *recessus cochlearis*
of Reichert. The recessus ellipticus is further bounded below
by a shallow furrow, the *sinus sulciformis.*

The Ampullar Mouths of the Semicircular Canals.—On the upper
wall of the vestibule, just above the recessus ellipticus, is the
ampullar opening of the superior semicircular canal; in the
angle between the posterior and inner wall near the inner open-
ing of the aquæductus vestibuli, is found the ampullar opening

of the common end of the superior and posterior semicircular canals. At about the same height in the centre of the posterior wall is the posterior opening of the horizontal semicircular canal. The lower opening of the posterior semicircular canal is in the angle formed by the union of the posterior, the inferior, and the inner wall of the vestibule. The anterior ampullar mouth of the horizontal semicircular canal is in the outer wall between the oval window and the ampulla of the superior semicircular canal.

Maculæ Cribrosæ.—These are groups of fine microscopic openings through which the nerves enter the vestibule. The superior group is found at the upper spinous termination of the crista vestibuli; a second group is in the recessus sphæricus, and a third is situate at the ampullar opening of the posterior semicircular canal. Through the superior cribriform spot nervous filaments pass to the utriculus and to the ampullæ of the superior and the horizontal semicircular canals, through the middle cribriform spot nerves pass to the sacculus, and through the lower spot the ampulla of the posterior semicircular canal is supplied.

Reichert has described a fourth cribriform spot, in the upper part of the recessus cochlearis, near the origin of the lamina spiralis. This gives admission to a filament from the smaller branch of cochlear nerve, which is distributed to the septum between the sacculi in the vestibule.[1]

The Cochlea.—The bony cochlea may be described very briefly as an osseous canal twisted spirally two and a half times about a bony pillar. This shape closely resembles that of a snail-shell, and has suggested the name of the cochlea.

The bony cochlea may be divided into the spiral canal, modiolus, and the lamina spiralis ossea, which, projecting from the modiolus into the calibre of the canal of the cochlea, terminates above at the helicotrema in what is named the hamulus.

The Canal of the Cochlea.—The cochlear canal starts at the extreme outer and lower corner of the vestibule, and winding outward and forward makes in its first half turn the promontory of the inner wall of the tympanum.

¹ Henle, op. cit. p. 760.

Each turn of the cochlea is shorter than the previous one, and rising above and beyond it outwardly forms the peculiar resem-

Fig. 31.
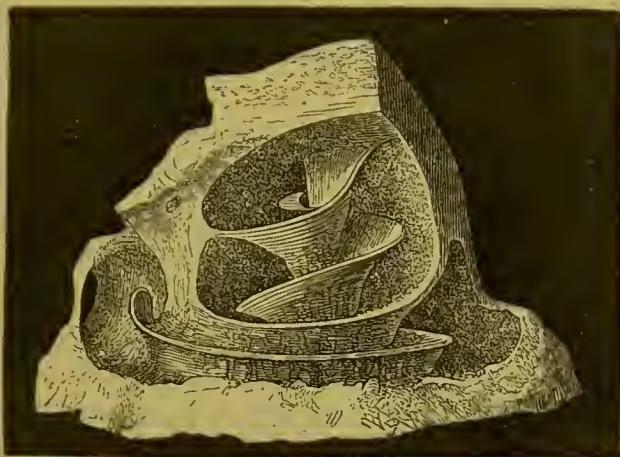
OSSEOUS COCHLEA LAID OPEN. (Magnified 4 diam.; Henlé.)

blance indicated by its name. The height of the cochlea is equal to the diameter of its base, and measures about 4 or 5 mm. The entire length of the cochlear canal is from 28 to 30 mm.

The *modiolus*, which may be considered as representing the axis of the cochlea, is nearly in the axis of the porus acusticus internus and about at right angles to the long diameter of the pyramid of the petrous bone. The point of the cochlea is directed outward, forward, and downward. The latter part of the cochlea, the cupola, is separated by a thin plate of bone from the canal of the tensor tympani muscle, while in front the coils are very close to the carotid canal. The diameter of the canal of the cochlea is about 1 mm. at its widest part; from the beginning of the last half turn it becomes much smaller. A transverse section of the cochlear canal varies in shape, being sometimes elliptical and at others semicircular. Its more common shape is that of a segment of a circle, the point of which is directed towards the axis of the cochlea. The thickness of the dividing wall between the turns of the cochlea is 0.3 mm. at the lower turn, and 0.03 mm. at the upper part of the canal.

The Modiolus and Lamina Spiralis Ossea.—The general shape of the modiolus is pyramidal. At its base the diameter is 2 mm., at the apex ½ mm., and its height is 2½ mm.

The modiolus is not only the bony axis about which the cochlear canal is twisted, but it is traversed by numerous canals for the transmission of the branches of the cochlear nerve, which is finally distributed like fringe on a bony shelf running spirally around the modiolus and projecting into the canal of the cochlea. This bony shelf is the lamina spiralis ossea.

The Scalæ.—The lamina spiralis ossea divides the canal of the cochlea into its scalæ. The upper one of these is the scala vestibuli, beginning at the vestibule and continuing to the helicotrema; the lower one, the scala tympani, may be said to begin at the helicotrema and end at the round window.

The general relation of the spiral bony lamina to the scalæ, and the relation of the latter to each other, will be understood, perhaps, better if the reader imagines himself starting from the vestibule along the upper surface of the bony partition between the scalæ, and continuing until he reaches, at the helicotrema, the sharp hook-like end of the bony lamina. At this point he must imagine that what has been the floor of the scala vestibuli now becomes the upper surface or roof of the scala tympani.

If the scala tympani be traversed, in imagination, two and a half turns will reach the membrane of the fenestra rotunda.

The lamina spiralis ossea forms only part of the division between the scalæ; as it does not pass as a bony septum from the modiolus to the opposite wall of the canal, the separation of the two scalæ from each other is not complete until the soft parts are added to the osseous structures. The lamina spiralis is thicker at its lower end than at the top of the modiolus. At the former point it may amount to 0.3 mm., but at the upper part, only to 0.15 mm. The width of the lamina spiralis is 1.2 mm. at the lowest part, and 0.5 mm. at the upper part.

The Semicircular Canals.—To the posterior part of the vestibule are attached the three semicircular canals. These are named according to their positions and planes, the superior, the posterior, and the horizontal semicircular canal.

Although there are three distinct canals, there are but five openings from them into the vestibule. This is due to the fact that two of the canals, the superior and the posterior, are joined to a common shaft just before they reach the vestibule. The

position of these openings on the wall of the vestibule has been described already (p. 125). At one end, each of the canals has a dilated portion, its ampullar enlargement. These enlargements contain soft parts of similar name and shape, the ampullæ of the membranous semicircular canals. The latter will be described later.

Dimensions of the Semicircular Canals.—The length of the posterior semicircular canal is the greatest of the three, amounting to 22 mm. The length of the superior canal is 20 mm. and that of the horizontal canal is only 15 mm., as shown by Hushke and Henlé. The common shaft of the superior and posterior canals is from 2 to 3 mm. long.

A transverse section of these canals is elliptical. The long diameter is to the shorter as 2 : 3 or 3 : 4. The longer measures, in man, from 1.3 to 1.7 mm. (Henlé).

Ampullar Enlargement.—The shape of the ampullæ is that of an ellipsoid. The ampulla of the superior and of the posterior canal is sharply defined from the rest of the canal as well as from the vestibule by a ridge, but the horizontal semicircular canal glides gradually into its ampullar end. The height of the ampulla, in the centre, is about 2.5 mm., not quite as great as the longer diameter of its calibre.

The Planes of the Semicircular Canals.—The superior and the posterior canals are in vertical planes at right angles to each other. The horizontal semicircular canal, as its name shows, is in a plane at right angles to that of both the others. The top of the superior canal points upwards, making thus a visible ridge on the anterior surface of the petrous bone. The top of the posterior canal points directly backwards, as does that of the horizontal semicircular canal.

Soft Parts of the Cochlea.—If a transverse section of the canal of the cochlea be examined under the microscope, the manner in which the canal is subdivided into its scalæ will be seen. This division is first indicated by the projection of the lamina spiralis ossea into the calibre of the canal. The free end of this bony shell would therefore form a good point for beginning the

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consideration of the topographical arrangement of the different parts of the cochlea.

Fig. 32.
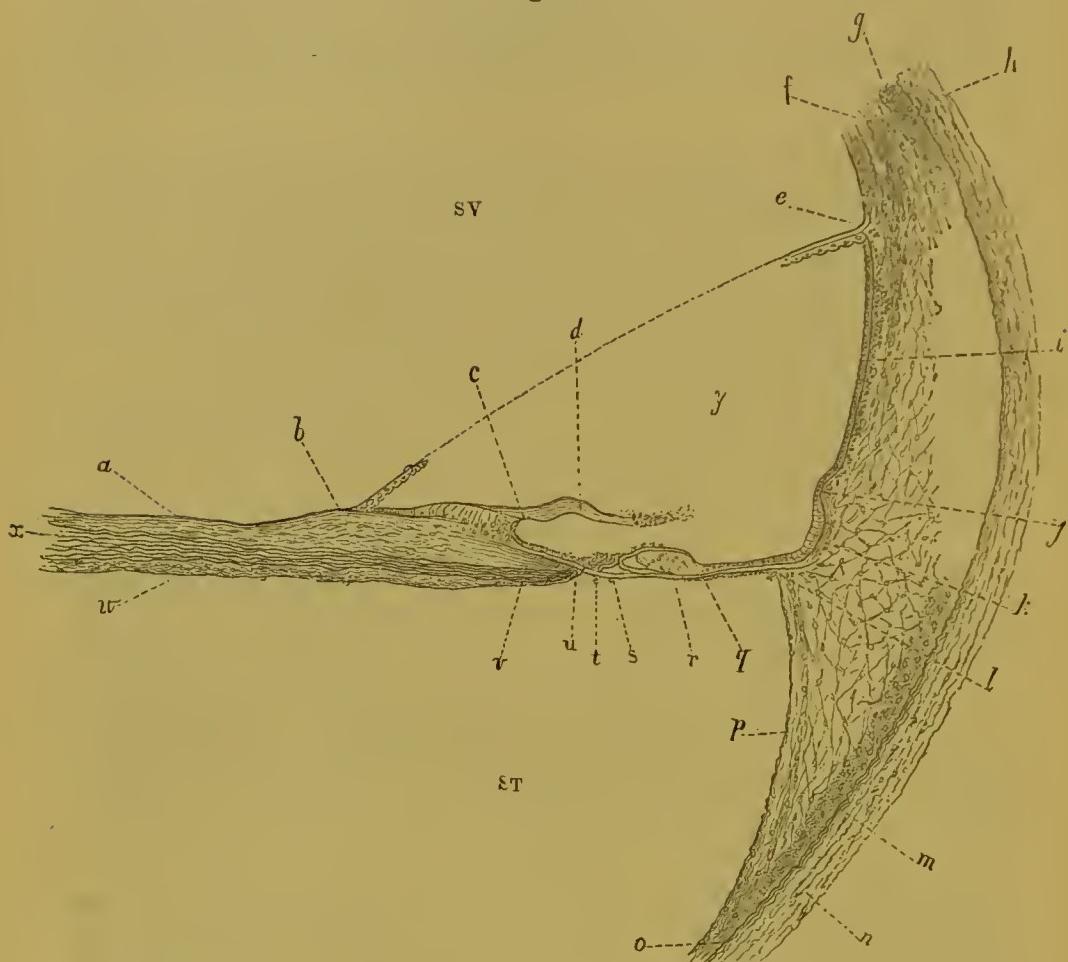
TRANSVERSE SECTION OF THE FIRST COIL OF THE COCHLEA OF A CHILD ONE AND A HALF YEAR OLD. (Magnified 100 diam.: Waldeyer.[1])—The membrana tectoria is sketched from another preparation of the same cochlea. SV. Scala vestibuli. ST. Scala tympani. *y*. Ductus cochlearis. *a*. Vestibular lamella of the lamina spiralis ossea. *w*. Tympanal lamella of same. *x*. Cochlear nerve. *h, n*. Osseous wall of cochlea. *g, o*. Periosteum. *f, p*. Cushion of connective tissue (lig. spirale of Köllikor) partially loosened from the bony wall, and thickened near the ductus cochlearis, into a special fibrous mural layer for the latter. *i*. Stria vascularis. *o*. Point of union between the periosteum and the cushion of connective tissue. *l*. Lig. spirale; *Henlé*. *j*. Lig. spirale accessorium, with the vas prominens. *k*. Sulcus spiralis externus. *b, e*. Reissner's membrane only the two end pieces shown; the rest indicated by a dotted line. *b, c*. Crista spiralis. *c*. Its most prominent part in profile; the so-called "auditory teeth." *d*. Membrana tectoria. *v*. Sulcus spiralis internus. *u*. Point of entrance of the nerve (Habenula perforata). *u, l*. Membrana basilaris. *u, q*. Cortis organ. *c, q*. Zona denticulata. *t, r*. Zona arcuata. *q. l*. Zona pectinata with epithelium. *t*. Region of inner ciliated cells. *s*. Thinnest part of the membrana basilaris under Corti's organ. *r*. Region of outer ciliated cells.

[1] Stricker's Handbuch, etc., p. 922.

Soft Parts of the Lamina Spiralis Ossea.—Upon the upper surface of the lamina spiralis ossea is placed the vestibular lamella, and upon the under surface, is placed the tympanal lamella of the lamina spiralis ossea. Through the bone lying between these lamellæ runs the nerve on its way to its termination at the organ of Corti and the ciliated cells, a description of which will follow later.

The tympanal lamella is continued in the same plane, directly across from the under edge of the lamina spiralis ossea to the opposite wall of the cochlear canal. Here it is joined to the latter at the thickest point of a cushion of connective tissue called the ligamentum spirale of Henlé. The division of one scala from the other is now complete, by the formation of this, the *membrana basilaris*. This membrane does not seem to be very elastic, according to recent observations of Prof. Waldeyer. The upper or vestibular lamella of the lamina spiralis ossea is the thicker of the two. About half way between its origin and the point of the spiral bony lamina, the vestibular lamella is thickest, from which point it seems to taper to the edge of the bony shelf on which it lies.

At this thick part there rises a delicate membrane, the membrane of Reissner, which springs across the scala vestibuli, and is fastened at a point on the opposite wall of the cochlea about 40° above its starting point. This is a most important membrane, since it forms the upper or vestibular boundary of the ductus cochlearis.

The membrane of Reissner is said to consist of a thin connective-tissue basement lamella, rich in vessels. On its vestibular surface large-celled, serous epithelium is found, and on its tympanal surface a single layer of regularly arranged, cubic epithelial cells.

It will now be seen that the cochlear canal is really subdivided into three canals — the scalæ already named and the ductus cochlearis which is formed at the expense of part of the scala vestibuli. The ductus cochlearis may, therefore, be said to lie upon the membrana basilaris above the grand division line of the scalæ, and should indeed be imagined as slipped into a triangular-shaped canal lying between the scalæ at their outer edges. The scalæ are lined with periosteum covered with large flat epithelium. They are filled with perilymph, and are in

communication with each other only at the helicotrema in the cupola of the cochlea.

The ductus cochlearis is not in communication with them at any point; it begins and terminates in so-called blind ends. The scala tympani ends at the membrane of the round window, but the scala vestibuli is in free communication with the vestibule.

Crista Spiralis.—From the point where the membrane of Reissner is attached to the vestibular lamella of the lamina spiralis ossea, there extends a crest or ridge of connective tissue and developed epithelium called the crista spiralis, the serrated edge of which is called by some anatomists, "aural teeth."[1] From this free peculiar edge rises the membrana tectoria, which extends as far as the beginning of the organ of Corti.

The space between the crista spiralis and the point of junction between the lamina spiralis ossea and the membrana basilaris, is called the sulcus spiralis internus.

Corti's organ extends from the junction of the membrana basilaris and lamina spiralis ossea to a middle point on the former membrane. From this point the epithelial lining of the ductus cochlearis pursues a less complicated course outward and upward over the wall of the duct.

Just above the attachment of the membrana basilaris to the outer wall, at the spiral ligament, there may be seen a prominence known as the accessory spiral ligament, but which really seems to form a passage for a vessel named the *vas prominens*. Between these two points lies the sulcus spiralis externus.

Above the vas prominens, between it and the upper and outer attachment of Reissner's membrane, is found the *stria vascularis*.

Habenula Perforata and the Zonæ.—The habenula perforata is situate at the extreme thin edge of the osseous spiral lamina, and gives exit to the nerve-branches. The *zona denticulata* extends from the crista spiralis to the outer end of Corti's organ; the *zona arcuata*, from the inner to the outer ciliated cells; and the *zona pectinata* extends from the outer boundary of the organ of Corti to the spiral ligament of Henlé. These names

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[1] Gehörzähne of Hushke.

are descriptive of the appearance of the region extending from the crista spiralis to the ligamentum spirale, when viewed from above.

According to the investigations of Prof. Waldeyer, three varieties of tissue can be discerned in the first stages of development of the cochlea. At that time the most external layer is a cartilaginous mass connected with the base of the skull. In this mass is a collection of embryonal mucous tissue, within which is imbedded the epithelial labyrinth vesicle. From the latter, which at last becomes the sacculus, a hollow sprout lined with epithelium grows before the eighth week, and pushing its way into the mucous tissue is forced by the surrounding cartilage to *curl itself up into a spiral shape.* This is the first trace of the ductus cochlearis. At one point the cartilaginous capsule is not closed, and here the cochlear branch of the auditory nerve enters.

The bony portion of the cochlear capsule, according to Prof. Waldeyer, is divided into a compact inner layer, a tabula vitrea, and the more porous modiolus and lamina spiralis. In the latter is found the canalis ganglionaris, in which lies the spiral ganglion of the auditory nerve.

The inner surface of the periosteum of the canal is covered with a layer of simple, large, flat, nucleated cells, similar to those found on the surface of serous membranes.

Ductus Cochlearis.—From the foregoing description of the three divisions of the cochlear canal it must have been seen already that the most important of these is the ductus cochlearis. It is indeed from the epithelial lining of this important capsule that the highly organized contents of the cochlea are developed so as to be the recipients of the terminal filaments of the auditory nerve, after it passes the habenula perforata and reaches the cavity of the ductus cochlearis.

The most important of these structures is the organ of Corti.

The Marquis of Corti[1] was the first to describe this apparatus, and it has from that time justly borne his name. Kölliker and Deiters subsequently enriched the knowledge possessed respecting this important apparatus of the internal ear.

The best treatise on the structure of the cochlea and the dis-

[1] Von Siebold and Kölliker's Zeitschr. f. Zoologie, 1851.

tribution in it of the auditory nerve has been written by Prof. Waldeyer.[1] Dr. Gottstein, his colaborer, has added the most important facts concerning the ultimate distribution of the auditory nerve to the outer ciliated cells.

Organ of Corti.—The position on the membrana basilaris occupied by the organ of Corti has already been pointed out. (Fig. 32, *u–q.*)

An idea of the general structure and appearance of this wonderful central portion of the ductus cochlearis can be gained by consulting Fig. 33.

Fig. 33.
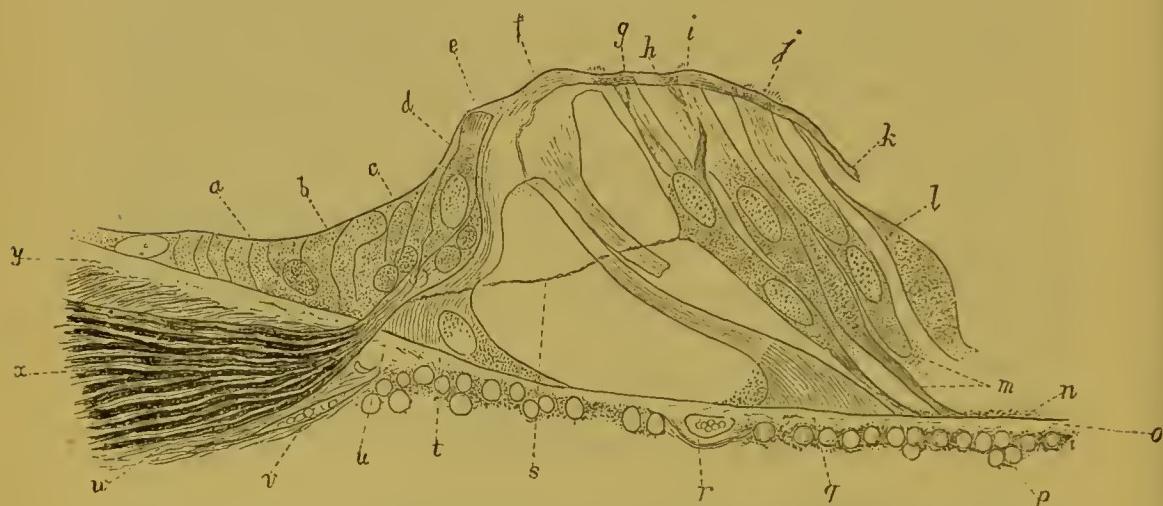
TRANSVERSE SECTION OF THE ORGAN OF CORTI. (Magnified 800 diam.: Waldeyer.)—*y, o.* Homogeneous layer of the membrana basilaris. *n.* Vestibular layer of the same, corresponding to the radii of the zona pectinata. *p.* Tympanal layer with nuclei, granular cell protoplasm, and transversely cut connective tissue fibrillæ. *y.* Labium tympanicum of the crista spiralis. *w.* Continuation of the tympanal periosteum of Lamina spiralis ossea. *u.* Thickened origin of the membrana basilaris immediately beyond the point of entrance of the auditory nerve *b. r.* Vas spirale. *v.* Bloodvessels. *x.* Nerve fasciculus. *a.* Epithelium of the sulcus spiralis internus. *d.* Inner ciliated cell. *c.* Its basilar process. About the latter and above the point of entrance of the nerve are some cells and finely granular matter in which the nerve fibrils are distributed (Granular layer). *e.* Inner part of the capital of the inner pillar and the point where the cilia of the inner ciliated cell are situate. *f.* Point of junction of the arches; the body of the outer pillar is severed in the middle; behind it appear the body and base of the next pillar at *q. t.* Base with part of the granular protoplasm of the inner pillar. *g, i,* and *j.* Three outer ciliated cells. *m.* Basilar part of two other ciliated cells. *l.* Hensen's supporting cell. *e, k.* Lamina reticularis. *s.* Nerve fibril distributed to the first ciliated cell, *g,* and traceable through the arch as far as the point of entrance of the auditory nerve at *b.*

The Pillars and Arches of Corti.—Upon the upper or vestibular surface of the membrana basilaris are two sets of pillars, an

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[1] Stricker's Manual of Physiology.

inner and outer row, uniting above and forming a series of arches. The pillars, as the arches, are named after Corti. They are about 3000 in number, according to Kölliker. A head, head-plate, foot, and body are parts into which anatomists have divided the pillars. At the junction of the pillars, the head of the outer is fitted into a depression between the head and head-plate of the inner pillar. (Fig. 33, *f*.)

The kind of tunnel thus formed by the arches of Corti is triangular in outline, the longest side of which corresponds to the membrana basilaris. This tunnel extends over the entire length of the lamina spiralis almost to the end of the hamulus, as given by Waldeyer. As a rule, the height and width of the arches increase towards the hamulus, as shown by Hensen.

Inner Ciliated Cells.—On the inner side of the arched roof thus formed, is found the single row of inner ciliated cells. The latter are lost at their lower end finally, in what is termed the " granular layer." Their upper ciliated ends are received into corresponding head-plates of the inner pillars. Their cilia, arranged in dense tufts or plots, are extremely stiff and strong.

The Outer Ciliated Cells.—There are five rows of the outer ciliated cells. They are arranged in parallel rows beyond the row of the external pillars, and underneath the membrana reticularis.

The Membrana Reticularis.—The membrana reticularis, as its name indicates, is a net-like structure. It is one of the most complicated parts of Corti's organ, extending from the junction of the pillars to the so-called support-cells at the outermost row of the ciliated cells. Into the meshes of this delicate reticulate membrane, fit the tufts of cilia of all the outer ciliated cells. A profile view of this arrangement can be seen in Fig. 33, at *i* and *j*.

The Surface of the Membrana Reticularis.—Viewed from above the membana reticularis presents not only a very beautiful but an equally complex appearance. It will be seen that the ciliated cells occupy alternate openings in the mesh of the reticulate membrane in both directions, thus giving a checker-board arrangement to the ciliated tufts and the intermediate spaces. To the former, the framework supporting the cilia, the name

ring has been applied by Böttcher, and the finger-shaped inter-spaces have been called the *phalanges* by Deiters. The latter are filled out by a delicate membrane according to Waldeyer. Over the entire organ of Corti, close to the membrana reticu-laris, is placed the membrana tectoria or Corti's membrane.

Membrana Tectoria.—Of this membrane Prof. Waldeyer states that it begins immediately at the point of attachment of Reiss-ner's membrane on the crista spiralis in the form of an immea-surably fine layer, covers the crista, while lying close to it, and at the same time increases greatly in thickness. It attains its greatest thickness in the sulcus spiralis internus, and terminates, as shown by Hensen, Gottstein, and Waldeyer, in a free and extremely delicate edge in the neighborhood of the outermost row of ciliated cells. (See Fig. 32, *d*.)

The constituent elements of Corti's organ have now been de-scribed as briefly and in as condensed a way as possible. Of this wonderful organ, Prof. Waldeyer says, that if there be left out of consideration the peculiarities of the inner ciliated cells, the apparently complicated structure of Corti's organ reveals really a simple plan. Several rows of cylinder-cells (double cells) are arranged in regular order on a broad zone of the spiral shelf. These rows are parallel to each other, and are held firmly in their position between two membranous boundaries, the membrana reticularis and the membrana basilaris. Two sets of these cylinder-cells, the pillar cells, become developed for the purpose of forming a firm arch of support for the whole. Specially worthy of note is the fixation of the outer ciliated cells, which, by means of processes and their head-piece, are immovably held between the membrana reticularis and the basilar membrane. These cells, together with the pillars of Corti, are the exclusive peculiarity of man and other mammals. To this apparatus, *i. e.*, to its peculiar ciliated cells, the terminal filaments of the auditory nerve are directly sent.

The Auditory Nerve; Origin and Distribution.—According to the investigation of Stieda in 1868, with whom Waldeyer agrees, the auditory nerve springs by two roots from the medulla ob-longata. The fibres of one of these are more delicate than those of the other. It originates from a ganglionic nucleus on

the floor of the fourth ventricle. The second root, which is said by Stieda to contain larger axis cylinders than any other nerve, springs from a special large-celled ganglionic nucleus in the crus cerebelli. This root acquires, soon after it leaves the medulla, a small ganglion like one of the posterior roots of the spinal cord. Both roots soon unite into a common trunk, but divide again in the porus acusticus internus, into two branches, the *vestibular* and *cochlear branches*.

Vestibular and Cochlear Branches of the Auditory Nerve.—The first contains a small ganglion, intumescentia ganglioformis Scarpæ, and divides into the ampullar branches and those for the utriculus and the sacculus.

The cochlear branch, which is by far the larger of the two, gives off a small fasciculus to the septum membranaceum between the sacculus and the utriculus, and to the macula cribrosa, and then enters the first turn of the lamina spiralis, from which point it continues its course throughout all the windings of the spiral lamina.

Inner and Outer Nerve-ends of the Cochlear Branch.—The ultimate fibres of the auditory nerve in the cochlea are named the inner and the outer terminal filaments, in accordance with their distribution to the inner and outer hair cells.

According to Waldeyer, both sets of fibres, as they emerge from the openings in the lamina spiralis ossea, pass through the "granular layer" which lies directly over their point of exit. The inner nerve fibres then pass directly to the inner hair cells. These fibres are large, and are considered as true axis cylinders. The outer nerve fibres are distributed, as shown by Gottstein, between the pillars of Corti, at about half the height of the arches, to the inner row of the outer hair cells, and perhaps to the more distant rows.

The origin of the auditory nerve, being so near the origin of the pneumogastric nerve, would help to explain the sympathy which seems to exist between an aural disease and the respiratory and the digestive tracts.

There also seems to be a sympathy between the ear and the emotions. May not cases of apparently hysterical deafness be traced to some such central nervous connection?

Soft Parts of the Vestibule and Semicircular Canals; the Membranous Labyrinth.—Since, in the consideration of the osseous structure of the internal ear, all of the latter has been comprised under the name of labyrinth, an analogous term might be applied to all of the soft structures of the internal ear considered as a whole. But Prof. Rüdinger, who has written the best treatise on the subject, limits the term " membranous labyrinth" to the sacculi and the membranous semicircular canals. In this sense, therefore, the term shall be used in the consideration of the soft parts contained in the vestibule and bony semicircular canals.

Fig. 34.
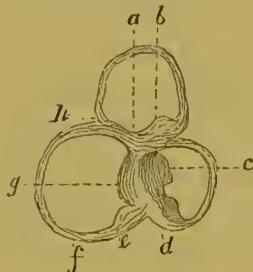
MEMBRANOUS LABYRINTH OF MAN. (Rüdinger.)—*l.* Horizontal semicircular canal. *e.* Superior semicircular canal. *b.* Posterior semicircular canal. *h.* Caualis communis. *a* Ampullar-like termination of the horizontal semicircular canal. *g.* Utriculus. *c.* Sacculus rotundus.

The membranous labyrinth, *i. e.* the sacculi and the semicircular canals, is now considered an important part of the perceptive auditory apparatus. Prof Rüdinger[1] has shown that these parts of the internal ear are in direct contact with the osseous or cartilaginous structures containing them, and that, therefore, they do not float, as heretofore supposed, entirely free in the perilymph.

The periosteum, lining the bony cavity containing these membranous parts, is a moderately thick layer of connective tissue, with some fine elastic fibres.

The Sacculi.—Of the sacculi, the utriculus is more closely connected to the inner wall of the vestibule than is the sacculus rotundus. The two sacculi occupy two thirds of the cavity of the vestibule. The utriculus extends further outward towards the tympanum, but neither of them touches the side of the vestibule which receives the base of the stapes, *i. e.* they do not touch the outer wall of the vestibular cavity.

The Membranous Semicircular Canals.—These are fastened to the convex side of the bony canals by means of stout connective tissue fibres, which are called by Prof. Rüdinger the *ligamenta labyrinthi canaliculorum.* These constitute the true support of

[1] Das häutige Labyrinth. Stricker's Handbuch. Leipzig, 1872.

the membranous canals. Sometimes there are two or more of these connective tissue stays, so arranged as to simulate under the microscope transverse sections of small canals. But they are to be considered simply as part of the support of the membranous semicircular canals. (Fig. 35, e.)

Fig. 35.
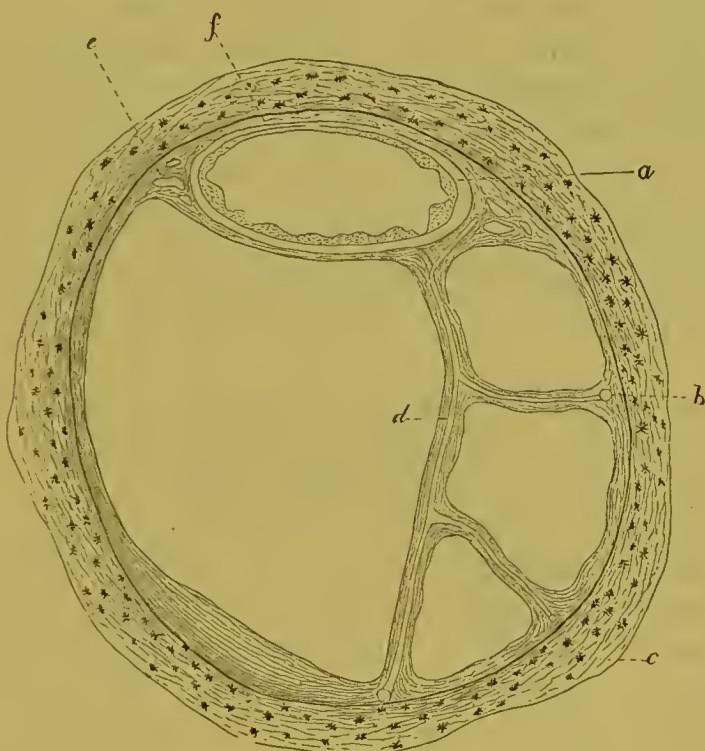
Transverse Section of the Bony and the Membranous Semicircular Canal of Man. (Rüdinger.)—c. Bony wall. d. Fasciculi of connective tissue inclosing vessels. b. Junction of fibres with periosteum. a. Membranous semicircular canal with its three layers. e. Ligamenta canaliculorum with their lacunæ. f. Junction of the membranous semicircular canal with the periosteum.

Another set of connective tissue fibres, passing from the periosteum to the free surface of the labyrinth wall, are for the purpose of supporting the bloodvessels as well as supplying points of fixation for the free wall of the membranous labyrinth.

Dr. Hasse has thought that he could demonstrate the existence of serous membrane in the labyrinth of the frog, but Prof. Rüdinger has not been able to satisfy himself on this point.

The wall of the membranous semicircular canals has an unequal

thickness, being 0.016 mm. at the point of contact with the perios-
teum ; it is thickest [0.060 to 0.080 mm.] at the point of junction
with the ligamenta labyrinthi canaliculorum. The canal wall
is composed of four layers in the following order from without,
inward, viz. : 1. A layer of connective tissue. 2. Hyaline tunica
propria. 3. Papilliform prominences ; and 4. The epithelium.

The external layer possesses all the qualities of connective
tissue with numerous cells. When the entire membranous
semicircular canals, removed from their connection with the
periosteum and ligaments, are subjected to examination, another
network is found, closely resembling nerves and ganglia. But
it is as yet very uncertain whether these are nerve-elements,
since the existence of nerves in the membranous semicircular
canals is as yet doubtful.

The tunica propria is of unequal thickness in the semicircular
canals, but in the utriculus it is of uniform as well as great
tenuity.

The papilliform prominences, on the inner surface of the
tunica propria, are considered by Prof. Rüdinger as normal
structures in the adult human being. (Fig. 35, a.)

They are so constant in their occurrence that their absence
and not their presence is to be considered pathological. They
are confined to certain parts of the wall of the canal, are varied in
size and shape, and pass imperceptibly into the tunica propria, of
which they must be considered a part. They attain their greatest
size at the point of insertion of the ligamenta canaliculorum.
They are not found on that portion of the tunica propria corre-
sponding to the part of the canal in contact with the bony wall,
and are but slightly developed on the free side of the membran-
ous canal.

The papillæ are covered with pavement epithelium, which is
easily detached ; and hence, perhaps, the assertion on the part
of some observers, that epithelium does not exist at this point.
These bodies are not found in the sacculi, nor at that part of the
semicircular canals where the latter pass into the utriculus.
Although these bodies may not be found in the new-born child,
and are considered pathological by some, Prof. Rüdinger says he
has never failed to find them in the adult human being.

The absence of epithelium, and the reaction between these
bodies and iodine, have been urged as proof of their starchy

nature.   But Prof. Rüdinger has demonstrated that epithelium can always be shown to be present with these bodies by the application of the proper tests ; and as far as iodine is concerned, that gives the peculiar reaction alluded to, in common with the tunica propria and many other tissues, in which the presence of starch has *never* been proven.

In conclusion Prof. Rüdinger says their round form can never be adduced as a proof of their amyloid nature, and if the inner surface of the membranous canals possesses a secerning nature, these bodies will supply a larger surface demanded by such a function.   These papilliform bodies are not found in the lower mammals.

Sacculi and Ampullæ ; inner Surface.—On the inner surface of these organs there is found a constant and peculiar yellowish

Fig. 36.
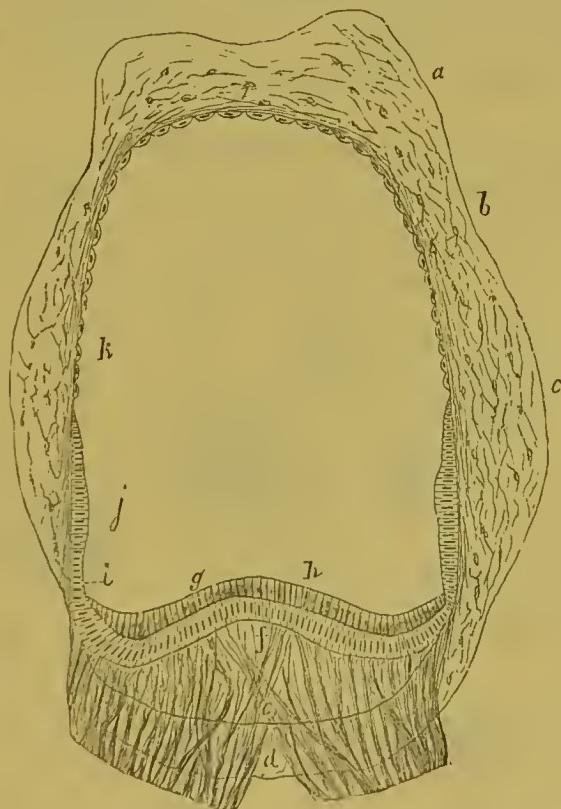
TRANSVERSE SECTION OF AN AMPULLA OF A FISH : FLOOR AND WALL. (Rüdinger.)—*a.* Roof of ampulla. *b.* Thin spot on its wall. *c.* Thick portion of wall. *d, e,* and *f.* Floor with the nerves. *g.* Nerve-epithelium. *h.* Acoustic cilia. *i.* Transition point between floor of ampulla and *j* planum semilunare. *k.* Flat epithelium.

epithelium provided with cilia. There is also found a redupli-
cation of the tunica propria extending into the cavity of the
ampullæ to which the name of *crista acustica* has been given by
Max Schultze. A similar projection in the sacculi is called by
the same authority the *macula acustica*.

Every branch of the acoustic nerve, going to the ampullæ,
after dividing into two flat fasciculi supplied with ganglion
cells, passes through the tunica propria, and is then distributed
to the ciliated epithelium of the crista acustica.

Planum Semilunare.—At right angles to each end of the crista
acustica, extending along the walls of the ampullæ, there is an
elevation on the epithelial layer, named the planum semilunare.[1]

To this also, some of the terminal filaments of the auditory
nerve are conveyed, as shown by Rüdinger.

The epithelial layer in the sacculi is thinner than that in the
ampullæ. There are several varieties of epithelium in this layer,
as shown by Prof. Rüdinger. But here too, ciliated cells are
found, to which nerve filaments are sent.

The Otoliths.—In the endolymph of the sacculi, there are found
small crystals of carbonate of lime, called Otoliths.

Fig. 37.
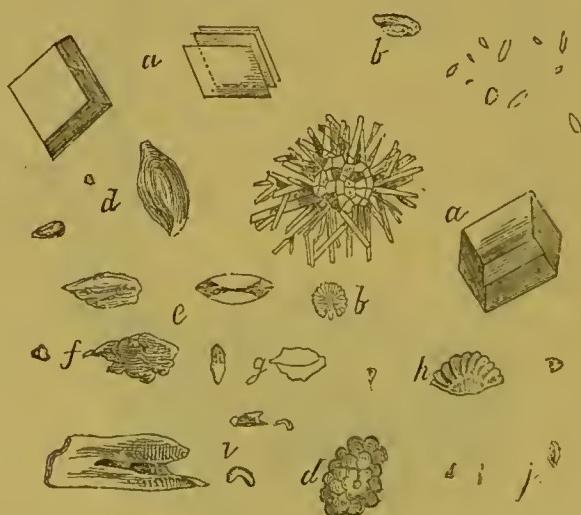
OTOLITHS FROM VARIOUS ANIMALS. (Rüdinger.)—*a*. Scymnus lichia (Leydig). *b*. Cyprinus,
carpio or carp. *c*. Goat. *d*. Roach ; fish. *e*. Woodgrouse (Leydig). *f*. Pike. *g*. Pterois voli-
tans (Breschet). *h*. Sea-devil. *i*. Mackerel. *j*. Herring.

[1] Steifensand, 1835.

Some observers have found otoliths in the endolymph of the semicircular canals and in that of the cochlea, but these are generally considered exceptional occurrences.

Henlé, after treating the otoliths with acids, thought he detected a cartilaginous remnant, to which the name of otolith cartilage is given.

They are, according to Rüdinger, large and few in reptiles, but small and numerous in man and other mammals.

The Topographical Arrangement of the soft Parts of the Internal Ear.—By consulting Fig. 38, the general relations between the soft parts of the internal ear may be learned. It will be seen that the sacculus rotundus pertains more to the ductus coch-

Fig. 38.
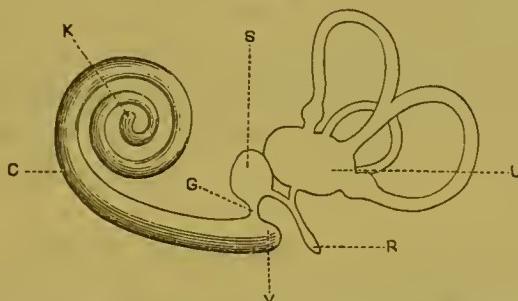
A Scheme of the Membranous Labyrinth of Mammals. (Waldeyer.)—U. Utriculus with the membranous semicircular canals. S. Sacculus. R. Aquæductus vestibuli. G. Canalis reuniens. C. Ductus cochlearis, with V. Vestibular cul de sac, and K. Cul de sac of the cupola.

learis than to the utriculus and the rest of the so-called membranous labyrinth. The link between the sacculus and the ductus cochlearis is the canalis reuniens of Hensen.

The aquæductus vestibuli is the roundabout way from the utriculus to the sacculus. Of this peculiar duct more will be said hereafter. The utriculus, as shown in the diagram, is the cavity with which the membranous semicircular canals and their important ampullæ are in close connection. The entire membranous labyrinth is filled with endolymph.

The Endolymph.—The general plan upon which the endo- and perilymph of the inner ear are renewed, has been best explained by Dr. Hasse, of Würzburg.[1] He has shown that all vertebrates possess a duct, which originates in the vestibule; and in

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[1] Anatomische Studien, No. xix. p. 768.

all animals, with the exception of the plagiostomes, in which it passes directly to the surface of the skull, this duct enters the cavity of the cranium, and there terminates either in a closed sac at the confines of an epicerebral lymph-cavity or opens into the same. This is the *ductus endolymphaticus* or the *aquæductus vestibuli*, with the *saccus endolymphaticus*, the former of which arises from the sacculus rotundus in most vertebrates, and conveys endolymph to the membranous labyrinth.

Physiological Functions.—Dr. Hasse has suggested three probable functions of the aquæductus vestibuli, or the endolymphatic duct.

1. The endolymphatic duct and its sac are the source of the endolymph in embryonal life. In this capacity, the sac plays the part of a kind of gland.

2. In adult life, this duct may act as a conveyer of new material to the endolymph, either by endosmosis from the epicerebral cavities in those instances where the saccus endolymphaticus is closed, or by means of a direct current where the saccus is open.

3. It may be supposed that the sac is useful as a reservoir for the liquor endolymphaticus, when the intra-labyrinthal pressure attains an excessive height. By the reception of the fluid into this sac, the pressure would be reduced in the labyrinth.

A very practical deduction is made by Dr. Hasse, respecting the ductus endolymphaticus. Every increased or diminished pressure of the cerebro-spinal fluid in the subarachnoid cavity will make itself felt by continuity through the saccus and the ductus endolymphaticus, in the interior of the auditory apparatus, in the endolymphatic cavity, and upon the terminal filaments of the auditory nerve. Thus may be explained the impairment of hearing for high notes when the pressure in the labyrinth is increased.[1] Furthermore, pathological processes in the subarachnoid space are conveyed either by continuity or contiguity through the saccus and ductus endolymphaticus, into the interior of the labyrinth, and *vice versa*, the latter being the rarer, from the deep-seated position of the inner ear. Thus, every alteration in the chemical constitution of the cerebro-spinal fluid,

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[1] See pp. 98–100.

necessarily produces a change in the liquor endolymphaticus, which alteration may exercise some influence in the occurrence of subjective acoustic perceptions, but in any event, must change the composition of the endolymphatic fluid.

The Perilymph.—The perilymph is poured into the labyrinth from the subarachnoid space through the foramina acustica, and leaves the labyrinth by means of the aquæductus cochleæ.

The perilymphatic cavity is inserted into the lymphatic tract of all vertebrates,[1] and being in connection with the subarachnoid space, it is easily seen how changes of any kind in the cerebro-spinal fluid can be communicated to the perilymph and thence to the organ of hearing. Hence, morbid processes in the subarachnoid space may be communicated to the organ of hearing, either by the peri- or endolymphatic tract, or by both ways at the same time. In this manner a not unsound explanation may be given of numerous affections of the internal ear.

PHYSIOLOGY.

Cochlea.—The physiology of the perceptive part of the organ of hearing has been explained most satisfactorily by Helmholtz and Hensen, the latter having made a series of experiments upon the function of hearing in the crab and lobster, since, upon the surface of these animals there are largely developed cilia, endowed with peculiar vibratile functions, and probably connected with the organ of hearing.

It is now generally conceded that the cochlea enables man to perceive musical notes, or notes and sounds with regular periodic vibrations, and that the membranous labyrinth is concerned in the perception of irregular vibrations, which are distinguished as noises. In the labyrinth, the distribution of the acoustic nerve may be traced to particularly firm and elevated spots at five different points, viz., in the two sacculi and three ampullæ. Imbedded in these elevated spots and in connection with the nerve-fibres centring there, are peculiar, stiff, elastic hairs or cilia, which are very brittle and pointed. Of these cilia, Helmholtz says: "Such delicate, stiff hairs are apparently in a high

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[1] Hasse, op. cit., p. 815.

degree susceptible of being moved by the motions of the fluid in which they are, and, in consequence of such movements, they produce a mechanical irritation of the nerve-fibres lying imbedded in the soft epithelium at their base."[1] Furthermore, there are found in close proximity to these acoustic cilia, calcareous bodies, the so-called otoliths, which, in the fish, bear an impress on their convex surface of the aforesaid prominence, containing the rich distribution of the acoustic nerve. In man, however, these otoliths only lie close to the wall of the membranous labyrinth. These crystalline bodies appear specially adapted to exert a mechanical influence over the nerve-filaments lying near them at each sudden movement of the water of the labyrinth, for, "the delicate and light membrane in which the nervous branches are interwoven, in all probability follows instantly the motion of the labyrinth water, while the heavier crystalline bodies, the otoliths, are set in motion more slowly and are longer in coming to rest. Hence they partly drag and partly press upon the neighboring nerves."[2] Thus a powerful and enduring excitation of the vestibular branch of the acoustic nerve is effected by means of the peculiar structure of that part of the membranous labyrinth containing it.

While considering the physiology of the cochlea, the terminal filaments of the cochlear nerve in the ductus cochlearis must be called to mind.

It will be remembered that in the nervous fringe lying on the lamina spiralis, there were certain arched supports of the delicate nerve ends on their way to the hair-cells. These, the arches of Corti, were stated to be about 3000 in number. It is supposed by Helmholtz, that each one of these arches is specially tuned so as to perceive a given note in the musical scale, just as in the piano-forte each wire is tuned to a note different from that of its fellows.

Although it is generally conceded now among physiologists that the arches of Corti have no sentient properties themselves, but are simply supports for the ciliated cells, which, being connected with the ultimate nerve-fibres, are the true sentient portions of the organ of Corti, nevertheless the arches may be

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[1] Die Lehre von den Tonempfindungen, p. 213.
[2] Helmholtz, op. cit., p. 214.

considered as representatives, in a topographical sense, of the terminal nerve-filaments, and Helmholtz's phraseology remains not only intelligible, but his theory extremely plausible.

"If," says Helmholtz, "we leave out of consideration two hundred of the arches of Corti, too high to be used in the ordinary musical scale, we still have 2800 for the seven octaves of the ordinary musical instruments, *i. e.*, 400 for each octave and $33\frac{1}{3}$ for each semitone; quite enough to explain the ability of perceiving fractional parts of a semitone, whenever such an ability exists. Skilled musicians, according to E. H. Weber, of Leipsic, can distinguish a difference between two notes, whose rates of vibrations are in the proportion of 1000 to 1001, equivalent to $\frac{1}{64}$th of a semitone, a quantity too small to correspond with the aforesaid interval between the individual arches of Corti. However, that does not militate against our hypothesis, for if a note is sounded, whose pitch lies between two neighboring arches of Corti, it will set both of them in consonant vibration, but that one whose fundamental note agrees most nearly to that of the note sounded will be set most violently in vibration. It will, in fine, depend only on the delicacy in the degree of excitability existing between two such nerve-fibres, and how small a difference in pitch in the interval between fibres we can distinguish. Thus it is we can explain the fact that when a note is continually rising in pitch, our perception of it changes gradually and not with jerking intervals, as it would if only one at a time of the terminal nerve-fibres were set in consonant vibration. . . . . The simultaneous perception of several notes of various pitches is due to the perceptive power of different nerve-fibres. Hence, the perception of clang-tint or timbre depends upon the fact that any note, besides setting in vibration that particular organ of Corti corresponding to its fundamental note, also excites perception in several different groups of nerve-fibres attuned to its partial tones."[1]

The theory of audition, as just described, has been further substantiated by the experiments of Hensen,[2] upon the organ of hearing in crustaceans, in which cilia endowed with acoustic

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[1] Helmholtz, op. cit., p. 230-231.
[2] Physiological Institute of Kiel, Germany.

power are situated on the external surface of the body. This investigator found that after he had destroyed the ear, or the saccules corresponding to that organ, in the mysis or opossum shrimp, but retained the external acoustic hairs or cilia on the antennæ, the power of hearing was still present in the animals. By conveying musical notes through water in a box in which a mysis was so fastened as to permit of examining the external acoustic hairs of its tail, Hensen perceived that certain notes of a horn, the instrument used in the experiment, would set certain acoustic hairs strongly in motion, thus demonstrating most forcibly the theory that in the perception of musical notes certain vibratile cilia and nerve-fibres connected with them are intimately concerned.

According to Prof. A. M. Mayer,[1] who has described a similar process in the so-called auditory apparatus of the culex mosquito, the process in both mysis and mosquito is only analogous to the process in the cochlea of vertebrates. In the organ of Corti there is in all probability a means of analyzing sound, whereas in the acoustic cilia of the crustacean and insect already named, there is supplied a means of conveyance of sound rather than an object to which sound is conveyed. Such physical facts were also alluded to by Dr. Christopher Johnson[2] in 1855, who believed that whenever auditory organs are developed in insects, their seat is near the antennæ.

To the question, "Are noises perceived in the cochlea, or is it correct to suppose the existence of another organ by which such sounds are heard?" the following conclusion is offered as an answer by Prof. Sigmund Exner.[3]

Physiologic acoustic facts force us to the alternative, either that in the ear there is a special organ endowed with the faculty of perceiving noises as such, or that the nerves of the cochlea are endowed with such a peculiarity of function. The latter supposition is deserving of preference, for in obedience to it the nerves of Corti's organ receive an excitation not only when the vibrations of those parts of the membrana basilaris which

[1] Researches in Acoustics, No. 5, p. 9; American Journ. Sciences and Arts. vol. viii. 1874.
[2] Quarterly Journal of Microscopical Soc., vol. iii.
[3] Zur Lehre von den Gehörsempfindungen. Pflüger's Archiv, xiii. S. 228. and Monatsschrift f. Ohrenheilkunde, No. 9, 1876.

underlie them have reached a certain length, but also at such a time as when the motion of the cochlear fibres becomes very rapid even by a slight impulse.

The sensation of a musical note occurs if only a few of the cochlear fibres are set in relatively slow consonance, but there occurs the sensation of an objective noise, whenever all the fibres of the membrana basilaris are hurried out of their position with relatively greater velocity.

Function of the Semicircular Canals.—The experiments of Flourens, in 1817, first drew attention to the probability that a lesion of the semicircular canals would produce peculiar disturbances in equilibrium of the body. His experiments were performed chiefly upon pigeons and rabbits, and consisted in wounding and irritating the semicircular canals and their contents. Subsequently his experiments were repeated by Harless, Czermak, Brown-Séquard, Vulpian, and Goltz. Without doubt many of their results, attributed to a lesion in the semicircular canals, were in reality attributable to injuries of the brain and other parts incident to the experimental operations; a fact which, indeed, Flourens appears to have recognized in his own labors.

With the experiments of Boettcher, in 1872–73, there begins an era of more careful manipulation and protection of the brain and the vessels about the semicircular canals during the investigations. This endeavor to exclude results due to lesions of parts other than the semicircular canals has been paramount in the recent labors of Bloch, Cyon, Mach, Berthold, Breuer, Curschmann, Löwenberg, and Bornhardt; and to these men belongs the honor of having conducted the most brilliant physiological experiments of modern times.

Flourens noted that wounding the horizontal semicircular canals was followed by to and fro horizontal movements of the head, and that section of the vertical horizontal canals was followed by a vertical movement of the head upward and downward. He was led to conclude that he had found a new pair of nerves in the semicircular canals, "endowed with the singular faculty of influencing the direction of motion" (doué de la faculté singulière d'agir sur la direction des mouvements).[1] He

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[1] Recherches expérimentales, etc., p. 493, 2d edition, 1842.

also stated that destruction of the semicircular canals in no way
affected the sense of hearing unless it was to render it more
sensitive. The experiments of Harless[1] and Czermak[2] were in
the main corroborative of those of Flourens; though Harless
concluded that he had observed a form of disturbance different
from those of Flourens, yet dependent upon a lesion of the
semicircular canals. Brown-Séquard[3] then endeavored to show
that it was a coincident dragging and wounding of the acoustic
nerve, in these experiments, which produced the peculiar alter-
ations in co-ordination of movements; but Schiff[4] thereupon
stated that wounding of the acoustic nerve, so long as the fifth
pair was left intact, had no effect upon movements of the body.
He also denied the existence of a nerve in the semicircular canals
endowed with the peculiar power of co-ordinating muscular
movements as was held by Flourens.

By wounding the semicircular canals, Vulpian[5] obtained
results similar to those observed by Flourens; but he explained
them as being due to disordered sensations of sound. This
view, however, has not appeared tenable in the light of sub-
sequent experiments by others; it is especially opposed by
Boettcher.

Goltz,[6] after a series of experimental sections through the
semicircular apparatus of the internal ear in birds and frogs,
not only doubted whether the semicircular canals are organs of
hearing, but advanced the theory that they constitute an ar-
rangement which serves to maintain the equilibrium of the head
and mediately of the entire body. In his opinion these canals
have more control in regulating the carriage and movements of
the head, than the senses of feeling and sight.

The investigations of Boettcher[7] and Bloch[8] were undertaken
with a view of repeating Flourens' experiments; of discovering
upon what the peculiar manifestations he had obtained de-
pended; and of finding out an explanation of them.

[1] Wagner's Handwörterbuch d. Physiologie, vol. iv.
[2] Comptes rendus, 1860, and Jenaische Zeitschrift, 1867.
[3] Lectures on Nervous System, Philadelphia, 1860, p. 195.
[4] Lehrbuch d. Physiologie, 1858-59, p. 399.
[5] Leçons sur la Physiologie, p. 601.
[6] Pflüger's Archiv f. Physiologie, Bd. iii. pp. 172-193.
[7] Kritische Bemerkungen, Dorpat, 1872.
[8] Repetitions of Flourens' Experiments, Dorpat, 1872-1873.

The preliminary labor of Bloch, was followed by a more
extended series of experiments by Boetteher. The latter has
shown that previous observers have not been fully aware of the
injury done to the soft parts, surrounding the semicircular canals,
especially to a certain portion first described in this connection
by Schklarewsky, and named by him the cerebellar process.
He thought that many of the phenomena obtained by previous
observers were really due, not to lesions of the semicircular canals,
but to an injury of the above-named portion as he supposed of
the cerebellum, extending into the cavitas meso-otica.[1]   Boett-
cher claims that this cerebellar process is nothing more nor less
than the aquæductus vestibuli.

Boettcher's experiments are further characterized by great
care in avoiding injury of all other parts, especially of blood-
vessels, and also by a thorough and continued observation of
each case operated on, until either recovery or death ensued.   In
the latter event the pathological anatomy has been fully studied,
and its importance acknowledged.

Boettcher divides his experiments into three groups : 1. Those
cases in which, partly by accident and partly intentionally, the
artificial lesion was considerable ; in these cases the results were
similar to those obtained by Goltz.   (2) Those cases in which
notwithstanding great precaution the operation was incomplete,
in so far as that after section of the semicircular apparatus on
both sides, very different, but very distinct disturbances in
motion occurred and alternated with each other.   They were,
however, entirely independent of each other.   (3) This last
group comprises those cases in which, after section of the semi-
circular canals on both sides of the head, only very insignificant
disturbances in motion occurred, which completely vanished
after they had persisted for a short time.

The conclusions drawn by Boettcher from his investigations
are as follows :—

1. The twisting of the head to one side and the accompany-
ing resting it on the ground, so that the top of the head touches
the ground and the beak points more or less backward, can be

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[1] A space described by Schklarewsky, as peculiar to birds, bounded by the
semicircular canals, in direct connection with the cranial cavity, and containing
an offshoot from the cerebellum.   Göttinger Nachrichten, 1872, No. 15.

produced by cutting the canals on one side, if the operation is performed roughly, but if the canals are cut with great care and without simultaneous injury of other parts, the above phenomena will not appear.

He concludes, therefore, that the twisting of the head is not a symptom of section of the semicircular canals. Since, however, this peculiar rotation of the head does occur some time after the operation, it must be attributed to secondary changes in the contents of the skull. In such cases he has found either extravasations on the cerebellum or the medulla oblongata, or inflammation of the membranes of the brain.

2. The direction of the rotatory movements and the movements of the body backward and forward about the transverse axis was shown to be dependent upon the canal cut, as was first discovered by Flourens; but they are independent of anatomical changes in the cavity of the skull. Nevertheless, they are not due to section of any two corresponding canals, i. e., not to the destruction of their function. Boettcher does not say, that the cutting of the canals is not the cause of the occurrence of these disturbed movements; in fact he believes that it is the cause; but the disturbances which follow are evidently due not to the injury of the labyrinth purely, but to other changes almost inseparable from it. In proof of this it is stated: (a) that after section of the semicircular canals on both sides the disturbances in motion which have begun may entirely cease, and the animals experimented upon recover. If the vertigo and disturbed movements were due to the section of the canals, they should persist.

(b) The fact that the disturbances in motion are observed always in the extremities on the side operated on is urged as further proof that not the section of the canal alone is the cause of the altered muscular movements.

(c) Again, the motor disturbances are observed in some cases in both walking and flying, in other instances only in walking or in flying. This is urged by Boettcher as a striking proof that vertigo cannot possibly cause the disturbances in motion; for if it did both acts would be equally interfered with. The lesion, therefore, is supposed by him to be purely a local one, affecting only either the legs or the wings.

(d) Finally, it is worthy of note that the character of the disturbance in motion is not dependent upon which of the semi-

circular canals are cut, but upon the point where the section is made.

The pendulum movements of the head are only a passing symptom, occurring with greatest intensity immediately after the operation, but gradually diminishing and finally ceasing. These pendulum movements persist in some cases, in which at no time the head of the animal is held in an abnormal position. In some instances, notwithstanding that the canals are cut on both sides, these peculiar movements do not occur. If rotation of the head occur, then the pendulum movements cease.

The twisting of the head and the tumbling usually connected with it, occurring after section of the semicircular canals, are attributable either to a cerebral lesion produced at the time of the operation, or to pathological processes developed later in the deeper parts of the central nervous system.

The *mouvements de manège, i. e.*, going round and round in circles, like a horse in the circus-ring, and the tendency to fall forward or backward, are involuntary movements having their foundation in changes produced in the crura of the cerebellum by the section of the semicircular canals, as already pointed out by Flourens.

The pendulum movements of the head, to and fro in either a horizontal or vertical plane, are *connected* with the section of the semicircular canals, but Boettcher is not disposed to admit that their occurrence is dependent on such a lesion. His experiments, as he believes, show these last-named movements to be dependent on a sympathetic affection of the brain. Furthermore, the fact that pendulum movements are as a rule followed in a few days by twisting of the head, would seem to indicate that there is a common cause for both.

Cyon's[1] experiments induced him to come to conclusions similar to those of Vulpian, viz.: that the function of the semicircular canals is to inform the animal, by means of a series of unconscious acoustic perceptions, of the correct position of its head in space, and for this purpose each semicircular canal has an exactly determined relation to a direction in space. He also attributed the disturbances in motion which occur after section of the semicircular canals to direct results of the artificial injury,

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[1] Pflüger's Archiv, Dec. 1873, vol. viii. p. 306.

to involuntary movements resulting from the abnormal acoustic perceptions produced by the same means, and to consecutive manifestations produced by inflammation of the cerebellum, which sets in in a few days after operation.

To illustrate the physical phenomena of the semicircular canals, Dr. Breuer[1] has used a system of three tubular rings filled with fluid, placed at right angles to each other, thus gaining a fair representation of the semicircular apparatus of the labyrinth. If a rotary motion be given to such a system, currents of the contained fluid will occur in a direction opposite to that of the applied motion. Such movements in the lymph of the labyrinth are supposed to occur in every movement of the head, the measure of the current in each semicircular canal depending upon the plane in which the head is turned, and also upon the amount of rotation. A perception of the movements of the fluid of the labyrinth may furnish exact information respecting every turning of the head. The acoustic cilia are brought forward as the possible perceptive apparatus of this movement, for they are situated at a broad, smooth spot in the canal and project at right angles into its calibre. Thus from their position they would be especially sensitive to the variations of the currents in the endolymph, and it is known that they are connected with nerves, the terminations of which they represent.

In order to harmonize both of these facts with Goltz's theory, Breuer assumes that every current of the endolymph is perceived by the nerves of the ampullæ, that it produces an idea of the rotation of the head in the plane of the semicircular canal most implicated, in a direction opposite to the current, and that the perceptions of the six ampullæ of both labyrinths unite in forming a joint conception.

Prof. E. Mach[2] has seemed to add corroboration to the theories of Goltz and Breuer by a series of novel experiments upon man, which were published a short time before the results of Breuer's labors.

Mach suspended a chair in which a man could sit with ease, in a framework, so that the chair could be revolved about a

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[1] Wiener Med. Jahrbücher, 1874, Heft I.
[2] Wiener Sitzungsberichte, Nov. 6, 1873.

horizontal axis and fixed at any inclination. In addition, the entire framework with the chair could be revolved about a vertical axis. In many of the experiments the chair was covered by a paper box, which, following all the motions of the chair, prevented the person sitting in it from observing with his eye the motions of the apparatus in which he was seated.

The principal results of the experiments with this apparatus were the following :—

A revolution about the peculiar vertical axis of the body is perceived by the person experimented upon only so long as it is accelerated.

A continued and constant revolution is not perceived.

Retardation of the revolution is perceived as a revolution in the opposite direction.

It is apparent that these facts agree with the theories of Breuer. The sensation of revolution in the opposite direction is converted into the sensation of motion in the true direction, in two seconds, by a renewed acceleration of the original motion. This sensation, therefore, must continue a few seconds longer than the cessation of the retardation ; for otherwise, the new acceleration should produce immediately a sensation of revolution in the original direction. If we accept Breuer's hypothesis, we must suppose that by the law of inertia the currents produced in the semicircular canals continue some seconds after the force producing them has ceased.

If during the revolution about the vertical axis the head is inclined forward and then suddenly elevated at the moment the revolution ceases, in those cases where the revolution has occurred from the left, forward and towards the right, an impression will be gained that a revolution is occurring from the right, upward and towards the left, and the person thus experimented upon will fear that he is about to fall towards the left. This fact is also in harmony with the hypothesis of Breuer, and proves most strikingly that the position of the head is a measure of the sensations of revolution, and that the organ of these sensations must be found in the head. These two fundamental facts have already been observed by Purkinje. Furthermore, Mach has established, by the aid of his apparatus, the fact that we have, either with the body at rest or revolved with a constant velocity, a distinct consciousness of the direction of the

resultant accelerating force without the assistance of the eyes. A man sitting in Mach's chair was able to give, by means of an indicator projecting from the case, a tolerably correct statement as to the vertical direction in any of the variously inclined positions of the chair.

When the case containing the chair was revolved about a vertical axis situate at some distance from the chair, and when the face of the one experimented with was turned towards this axis, the axis then given by him as the vertical one was in reality one inclined diagonally downwards from the axis corresponding to the resultant of the centrifugal force produced by the revolution with constant velocity, and the weight of the body revolved.

Certain facts of a similar nature, perceived prior to this, induced Breuer to add to his hypothesis already described, the supposition that we should consider the macula acustica with the otoliths as possibly an organ for the perception of the position of the head at rest, in respect to the direction of the resultant accelerating forces and the rectilinear motions. In this portion of the acoustic apparatus he perceives the fulfilment of the necessary conditions and assumes that the otoliths are specifically heavier than the endolymph, and that they consequently have a tendency to sink in it in the direction of the resultant accelerating force. According to the direction of this force in the head, the otoliths would drag, in various ways, upon the hairs with which they are connected, and thus produce a varied excitation of the terminal nervous apparatus.

In addition to this, the specifically heavier otoliths would have, at the beginning of a rectilinear motion, a tendency to remain behind the endolymph, and at the cessation of the same they would go in advance of it, and therefore they would, by mechanical action upon the cilia, produce a perceptive sensation.[1]

Berthold's[2] experiments were performed with great care to avoid any implication of the central organ. He confirmed the above-mentioned statements of Schklarewsky and Boettcher, respecting the danger of wounding the aquæductus vestibuli; in order to avoid hemorrhage or any undue lesion he used silk

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[1] See abstract by Prof. Fick, Archiv f. Ohrenheilkunde, vol. ii. N. F. p. 306.
[2] Archiv f. Ohrenheilkunde, Band ix., 1874.

thread for cutting through the canals. *Manège* movements, consequent upon section of the semicircular canals, were not observed by Berthold, but vomiting was found to occur in cases where it could not be attributed to injury of the brain. He also observed that injury of the above-named " process of the cerebellum," or aquæductus vestibuli, alone produced symptoms partly resembling those resulting from injury of the semicircular canals. His final conclusions are in favor of regarding the function of the semicircular canals as assisting in the coördination of motion by means of reflex action. They perform their function in company with two other senses, viz., with that of sight and with that of touch.

The experiments of Flourens and Goltz, on pigeons, have been repeated by Curschmann,[1] who has observed three very important cautions in his investigation, viz.: 1. The least possible destruction of tissue about the semicircular canals; 2. The avoidance of excessive hemorrhage, especially from the venous sinus near the canals ; and, 3. The infliction of the least possible injury to the bony canals, since, from their intimate relation to the cavity of the cranium, they cannot be destroyed without a previous opening of this cavity, which is followed by an immediate or secondary injury of the cerebellum.

The conclusions of Curschmann are that : 1. Injuries of the semicircular canals are positively followed by disturbances in the equilibrium of the body ; 2. The phenomena are proportional to the lesions ; 3. The derangements are constantly observed in connection with muscular movements ; 4. The canal operated on, as well as unilateral or ambilateral destruction of the semicircular canals, determines the character of the resultant phenomena; 5. The phenomena are the more intense and defined, the more energetically the animal moves about ; 6. The phenomena of deranged coördination in muscular movements are expressed in the head, trunk, and limbs of the animal operated on ; 7. The supposition that the derangements of motion of the trunk are due to a defective carriage of the head is not tenable ; 8. After total removal of all three membranous canals on both sides of the head, the pigeons do not appear entirely bereft of the power to direct their movements; 9. Simple section of a

[1] Deutsche Klinik, No 3, 1874, Archiv f. Ohrenheilkunde, vol. ii. N. F. p. 307, abstract by Prof. Lucæ.

single canal, if the structure is not secondarily diseased, is followed in four or five days by a diminution, if not a total cessation, of the resulting phenomena, even without a *restitutio ad integrum* on the part of the incised canal; 10. The almost constant increase of, and frequent changes in, the original symptoms, appearing after extensive injury to the canals, are referable to subsequent disease of the remnants of the injured canals, or to secondary alterations of the canals which were left intact; 11. The semicircular canals are not to be considered as an organ of the sense of equilibrium; 12. The phenomena are the result of a cessation of function, not the result of an irritation, certainly not of a specific irritation of the acoustic nerve; 13. Since the hearing is not materially altered by a removal of the semicircular canals, it cannot be concluded that they are not connected with this sense.

Löwenberg's experiments[1] have led him to the following conclusions: 1. The derangements in motion, which manifest themselves after the semicircular canals are cut through, depend upon such section only, and not upon the accompanying injury to the brain. 2. Vomiting, which was noted by Czermak in his experiments, depends upon the attendant injury to the cerebellum. 3. The disturbances in motion are due to irritation of the semicircular canals, not to paralysis of them. 4. The irritation produces, reflectively, spasmodic paralyses, without participation of consciousness; fresh irritations of the canals are induced only by calling forth voluntary movements. 5. The conveyance of this reflex excitation to the motor nerves occurs in the thalamus. 6. Section of the auditory nerve does not produce these derangements of motion.

Bornhardt,[2] the latest experimenter upon the semicircular canals, is forced to conclude that the phenomena of deranged movements succeeding section of the canals are due to unavoidable injuries of other parts. He rejects the theories of Breuer and Mach, and is of the opinion that "the semicircular canals serve, by transmission of the *vibrations resulting from muscular contraction*, to intensify the muscular sensation during action of

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[1] Archives of Ophthalmology and Otology, vol. iii., part ii. pp. 26–44.
[2] Med. Centralblatt, May, 1875, and Blake's Report on Progress of Otology, American Otological Society, 1875.

the muscles of the head. The following experiments Bornhardt considers as confirmatory of this conclusion: The horizontal semicircular canal of a rabbit being exposed without injuring its osseous covering, and the back of a knife being rubbed backward and forward upon it, by which means it is merely agitated, the same movements of the head and eyes occur, which are characteristic of division of the membranous canal. The direction of the muscles attached to the head is parallel to the direction of the semicircular canals, which fact seems to favor the above conclusion. Movements similar to those resulting from division of the canals have been induced by an experiment which leaves the brain and osseous canals intact. The vertical and horizontal canals in pigeons were exposed to a continuous stream of ether by means of an atomizer; they were also touched by a red-hot needle. In both cases the same symptoms appeared as in division of the canals; the same result was also obtained by touching the canals with a vibrating tuning fork.

CHAPTER II.

SCHEME OF RELATIONSHIP BETWEEN THE MIDDLE AND INTERNAL EAR.

Schematic Description of the Middle Ear, of the Internal Ear, and of the relation they bear to each other.—In order to understand the general features of the middle ear and of the internal ear and the general relations they sustain to each other, let there be imagined, first, a broad and shallow barrel, closed at each end and divided in the middle by a partition.

If this barrel be laid upon its side with one end towards the reader, it will give a fair representation of the *middle* ear, in the near half, and of the *internal* ear in the far half. The head of the near half of this barrel will represent the membrana tympani or drum-head, while the partition in the centre of the barrel represents the inner bony wall of the tympanic cavity. In this partition let two openings be made, one oval-shaped, situated above and in front of the other which is round. The former represents the *foramen ovale* or the oval window, and the second, the *foramen rotundum* or the round window.

From the membranous head of the near half of the barrel to the partition in the centre, is stretched a bony bridge composed of three pieces. This of course is the chain of ossicles, containing the mallens or mallet, the incus or anvil, and the stapes or stirrup, and stretching from the membrana tympani to the inner wall of the tympanic cavity.

The handle of the outermost of the three ossicles, the manubrium of the mallet, is inserted into the fibrous or middle layer of the drum-head; the innermost, the stirrup, by means of its foot-plate, fits into the oval window in the inner wall of the tympanic cavity, and the middle bonelet, the anvil, is held in position between the other two. They are furthermore held together and fastened to the roof and wall of the tympanic cavity, by means of ligaments.

This bridge of ossicles may be said to have two guys which steady it and give it proper tension, one of which is fastened to the mallet and the other to the stirrup. The former will at once be recognized as the tensor tympani and the latter as the stapedius muscle.

In the outer half of the imaginary barrel are two bung holes, one in front, the other on the back. The front bung-hole represents the tympanic opening of the Eustachian tube, by means of which the middle ear, or drum, is ventilated, and the atmospheric pressure on each side of the drumhead equalized. The back bung-hole is the communication between the mastoid cells and the cavity of the tympanum.

Fig. 39.

AUDITORY OSSICLES IN CONNECTION: VIEWED FROM IN FRONT. They are supposed to be from the right side of a head turned slightly about the vertical axis towards the right. (Magnified 4 diam.: Henlé.)—*j.* Mallens. *k.* Incus. *l.* Stapes. *i*, Head, *h*, Neck, *g*, Long process, *f*, Manubrium of the malleus. *a*, Body, *b*, Short, *c*, Long process, *e*, Processus leuticularis of the incus. *d.* Small head of stapes.

The mastoid portion may be likened to an ivory box filled with sponge, the latter representing the series of bony cells, which communicate with each other and at last by means of the mastoid antrum with the cavity of the middle ear.

In this simple manner, the middle ear, with its ossicles and more important appendages, may be sketched.

The functions of this cavity are dependent on aerial life, and equal pressure of air on each side of the drum-head.

This air-containing cavity is separated from the internal ear, or labyrinth, a *water-containing* cavity, by means of a bony partition, viz., the inner wall of the middle ear already described, in which is the oval window, into which the foot-plate of the stirrup fits. Hence, these two important cavities have one wall in common through which, by means of the foot-plate of the stirrup, the movements of the chain of little bones are communicated to the fluid of the internal ear and to the thread-like ends of the nerve of hearing suspended in it.

In order to understand the general features of the internal ear, let us still retain the simile of the barrel. In this instance the inner half of the barrel must be regarded as made entirely of bone, as filled with water, and communicating at *no point* with the atmosphere, but in direct communication with the arachnoid space by means of the aqueducts of the vestibule and cochlea.

Since the walls of the internal ear are made of bone, there can be no giving on their part to the pressure of the fluid of the labyrinth produced by the movements of the stapes. In order that these movements may go on, there is found at the extremity of one of the passages of the internal ear, viz., the cochlea, the round window, over which is stretched a membrane which yields slightly to the pressure brought about in the labyrinth by the movements of the stapes.

On the front of this inner cavity representing the *internal ear*, is a spiral tube, with two and a half turns. Being wound around like a snail-shell, it long ago received the name of *cochlea*.

On the back of this inner cavity are found five openings communicating with three semicircular tubes. We would naturally look for six openings into the ends of three semicircular tubes, but only five are found in this instance, as two ends of two of the semicircular tubes, viz., the superior and posterior semicircular canals, join together and have a common opening into the internal ear or labyrinth at that part of it called the *vestibule*.

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On the far-head of this inner barrel-half, we find the nerve of hearing pushing its way into the labyrinth, through a *sieve-like spot.* After forcing its way into the cavity of the internal ear through this sieve-like spot in the inner bony wall of the internal ear, at the fundus of the internal auditory canal, the auditory nerve divides into two main branches, one of which, the cochlear branch, is distributed to the cochlea, and the other, the vestibular branch, is given to the sacculi and to the ampullæ of the semicircular canals.

PART II.

DISEASES AND TREATMENT.

SECTION I.

EXAMINATION OF PATIENTS.

CHAPTER I.

INSTRUMENTS AND METHODS OF THEIR EMPLOYMENT.

THE light employed in examining the ear is usually reflected into the auditory canal by means of mirrors, to be described later. But the ear may be examined by direct rays of light in such a way as to give considerable aid in some instances. If daylight is to be reflected into the ear, the light coming from the north will be found to be the most luminous. If, however, examination by direct rays of sunlight is desired, the ear must be so situated that the sun's rays may fall directly upon it. If artificial light is used, that of an Argand gas-burner will be found the brightest. The flame of a petroleum-burning student-lamp is also very good, but if neither of these can be commanded, a candle will render good service, especially at the bed-side, for it is much easier to move the light in examining a patient in bed than it is to adjust the head of the sufferer.

Examination of the Ear by means of Polarized Light.—This mode of examining the ear has been attempted by Drs. Hagen and Stimmel,[1] and they were able thus to effect the entire disappearance of the posterior-superior quadrant of the drum-head, and a consequent revelation of the long process of the incus and portions of the stirrup. Other portions of the membrana tympani appeared much thinner, and it was possible to determine the presence of adhesions and pseudo-ligaments in the tympanic cavity. By using this mode of examination, all opacities of the membrana tympani, such as calcareous spots, ecchymoses, and

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[1] See Report on Progress of Otology, by C. J. Blake, 1875.

Fig. 40.

KOLBE
PHILADA.
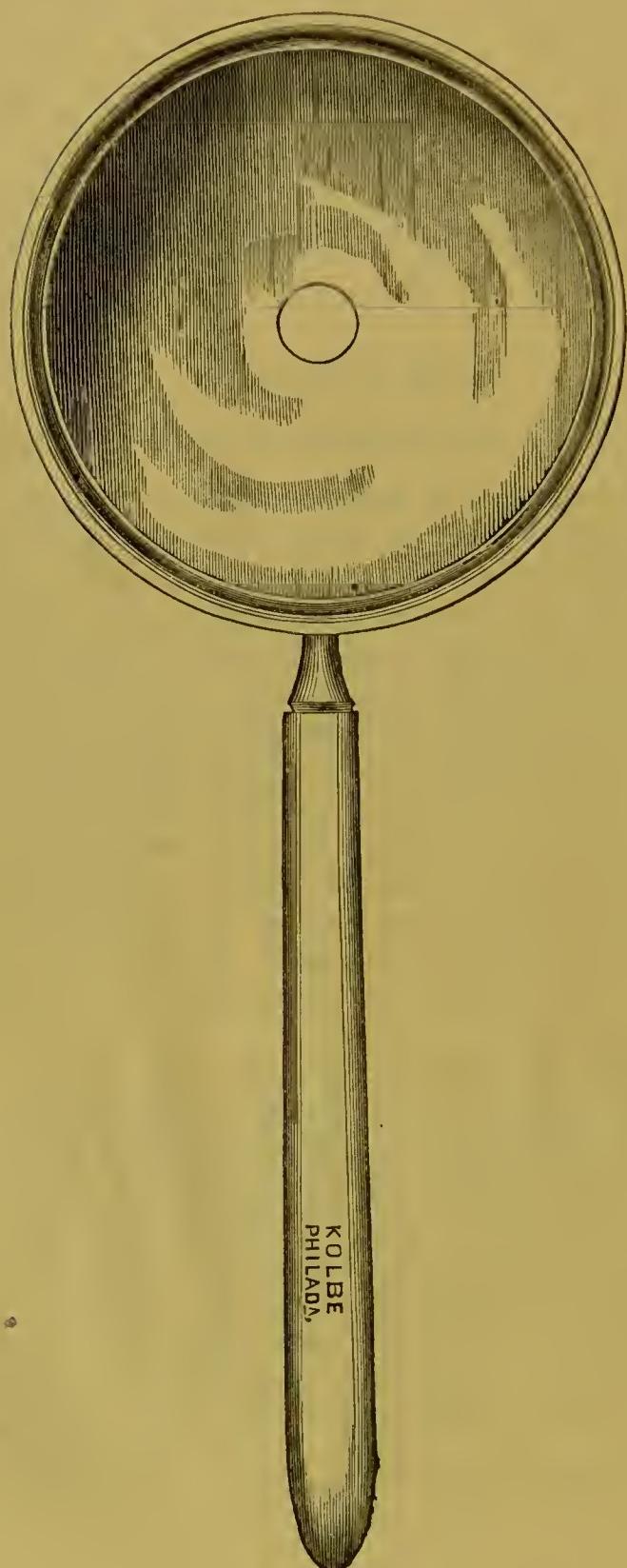
EAR MIRROR.

the like, appear more distinctly defined, and the bloodvessels of the manubrial plexus were more clearly visible. Transparent spots seemed to disappear entirely. From what has been done already with this mode of illumination of the ear, it would seem that it could be rendered of the greatest aid in diagnosis, if its application be not too complicated.

Instruments for Examining the Ear.—The instruments used in examining the ear should be as simple as possible. The first demand is for a concave mirror with a focal distance of from four to six inches, according to the eye of the examiner. That form known as Von Troeltsch's ear mirror is most widely used, and is the best. (Fig. 40.)

Otoscopes, or Aural Specula.—The next want will be a nest of specula or ear funnels. There are numerous forms found in the instrument makers' shops, under the names of Kramer, Toynbee Wilde, Gruber, Politzer, and others. While all are good, pre-

Fig. 41.
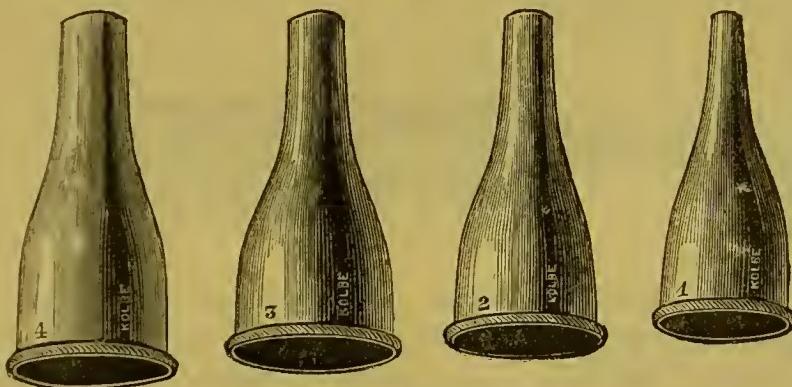
GRUBER'S AURAL SPECULA.

ference should be given to Gruber's specula, because a transverse section of their calibre at right angles to the long axis, most closely resembles a similar section of the auditory canal, *i. e.*, it is slightly ovoid in shape. The great object in using a speculum or aural funnel, is simply to hold the tragus away from the meatus, and to push away the stiff hairs about the opening of the external auditory canal. In some cases, moderate dilatation of the cartilaginous canal may be effected, but usually, all

endeavors at dilatation of the external auditory meatus are worse than useless—*they are painful and injurious.*

All forms of specula or ear funnels are made of metal and of hard rubber. Both kinds possess peculiar advantages as well as disadvantages. The first are less brittle than rubber, but they are colder in winter-time, and sometimes are objected to by the patient. On the other hand, the hard rubber ear-funnels, while being more agreeable in feeling to the patient, are extremely brittle. In some instances, ear-funnels have been made of glass. This kind would be as little likely as any to be affected by the various caustics sometimes used in the treatment of aural diseases. But when such substances are applied carefully to the ear, no speculum will suffer, for the latter need not be touched by the medicinal substance. In any event, the metallic specula will be more easily attacked by acids, nitrate of silver, and the like, than the hard rubber variety. In no case will it be necessary to oil the funnel before it is inserted into the meatus, for if it require greasing to make its way into the canal, then the instrument is either too large for the ear, or the auditory canal is too swollen to permit an examination by means of the ear-funnel.

Fig. 42.

BONNAFONT'S OTOSCOPE.

If magnification is desired, it can be neatly and cheaply obtained by the employment of Bonnafont's otoscope. The specula are adjustable, thus permitting the ready use of various sizes; these and the case are made of hard rubber. There is a magnifying eye-piece, and a perforated mirror for reflecting light into the auditory canal.

Siglé's Pneumatic Otoscope.—Dr. Siglé of Stuttgart, some time ago, invented a most valuable instrument, which is known in Germany as Siglé's pneumatic ear-funnel. It consists in a hard rubber, round speculum, like Politzer's, to which is attached an air-tight chamber 3 cm. in diameter. The upper, or outer wall of this chamber is glazed, and forms an angle of 40° with

the plane of the inner wall. On the longer side of the chamber there is an opening with a perforated knob, to which is attached a piece of rubber tubing about a foot in length, ending in a mouth-piece for the surgeon. This chamber is made to screw off and on ear-funnels of different diameters. When all the parts are fully adjusted, the surgeon has an air-tight speculum with a glass end, through which he can examine the movements the drum-head makes during condensation and rarefaction of the air, brought about by his own mouth through the rubber tubing at the side of the instrument. This is really the only means the surgeon has of fully deter-

Fig. 43.

SIGLÉ'S PNEUMATIC OTOSCOPE.

mining the mobility of the drum-head, though both Valsalva's and Politzer's methods of inflation, if carried out while the surgeon's eye is fixed on the drum-head, will give him some idea of the extent the membrane can move. But when the Eustachian tube is imper- vious, Siglé's instrument is the only means of determining the mobility of parts or of the whole of the membrana tympani.

Fig. 44.

Kramer's Ear-speculum.—There is sold in the shops an instrument under the name of Kramer's ear-speculum. Its inventor, Dr. Kramer of Berlin, designed it for use only in the direct rays of sun- light. This, of course, renders it an instrument of very limited usefulness respecting the ear. As it is a bivalvular instrument, and designed there- fore for dilatation, it will slip from the meatus as soon as the handles of the instrument are brought together, or else great pain will be caused by its use. It is an admirable aid, however, in anterior rhinoscopy.
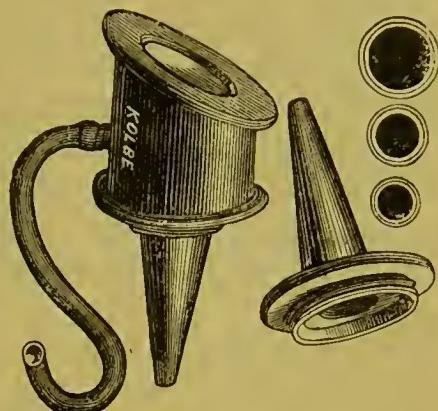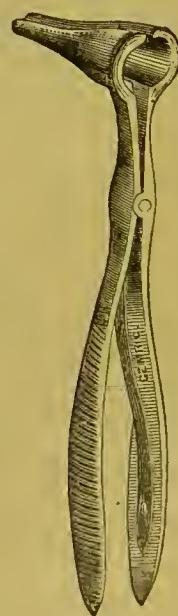
KRAMER'S
SPECULUM.

Blake's Operating Otoscope.—Dr. Clarence J. Blake's operating otoscope is intended to overcome the disadvantages of the usual monocular examination of the ear. "It consists of a hard rubber speculum (Politzer's) of the largest size, fitted with a metallic rim, to which is attached a revolving prism and an arm, bearing at its outer end a lens of about an inch focus; this arm is movable, but sufficiently firm to remain fixed at any angle at which it is placed. The prism is just within the focal distance of the lens, and its incident face is armed with a small metal shield, having an opening in the centre corresponding in its short diameter to the diameter of the pencil of light falling upon it from the lens. The advantage of the prism over a mirror or other reflecting surface is, that we have almost total reflection, and but little of the light concentrated upon the prism by the lens is lost.

"In operating, an assistant is required to draw the auricle upward and backward, and keep the speculum in position, with the funnel of light upon the opening in the shield of the prism. It is not claimed for the instrument that it at all supersedes the head mirror of Von Troeltsch, but it is certainly of great advantage in the more complicated operations, when a steady and uniform illumination is indispensable. The instrument, as a whole, weighs only about one hundred and twenty grains, and can be made much lighter; so that when once firmly inserted in the meatus, it remains in position, and there is no necessity for holding it nor fear of its slipping out of place during the operation."[1]

Dr. E. De Rossi,[2] Professor in the University of Rome, claims to have invented a binocular otoscope. It is simple and inexpensive, differing very slightly from the original form of Helmholtz's ophthalmoscope. It is so arranged on a forehead-band as to allow the use of both hands, but the distance of the eye from the membrana tympani, thirty centimetres, necessary to obtain a binocular view, renders the instrument of no very great practical utility.

Voltolini[3] has devised a pneumatic aural speculum, which is

[1] Roosa's Treatise, p. 87, 1873.
[2] Ein einfaches binoculäres Otoscop. Monatsschr. f. Ohrenheilkunde, No. 7, 1872.
[3] M. f. O., No. 2, 1873.

a compound of Siglé's pneumatic speculum and Brunton's speculum. With this he proposes to investigate more thoroughly and most boldly the middle ear, after cutting away the posterior segment of the membrana tympani and turning it forward over the hammer. He thus obtains a more perfect view of the fenestræ of the labyrinth and of the stapes. He also proposes to operate with this speculum in situ, by introducing a knife through a slit in the funnel portion of the speculum. He reports one case of tenotomy of the tensor tympani performed successfully by its aid. If the instrument is all the inventor claims it to be, it may be considered a valuable addition to the diagnostic as well as surgical means of otology.

The middle-ear mirror of Blake[1] is the modification of the laryngoscope and rhinoscope, applied to the exploration of the tympanum with reflected light. The mirrors are of three sizes, as represented in the wood-cut, and are of polished metal. The mirrors are made so as to be flexible at the junction with the shaft, and are thus adjustable at any angle best suited for examining the various walls and the roof of the tympanic cavity. By placing the shaft in a tenotome handle of Weber-Liel, the mirror can be rotated as desired, by moving the thumb-piece on the ivory handle.

Under thorough illumination of the auditory canal, these mirrors can be carried into the tympanic cavity if the membrana tympani be destroyed, and by careful manipulation the condition of the cavity may be studied. They are specially adapted to the search for, and examination of small polypoid growths on the roof of the cavity.

Fig. 45.
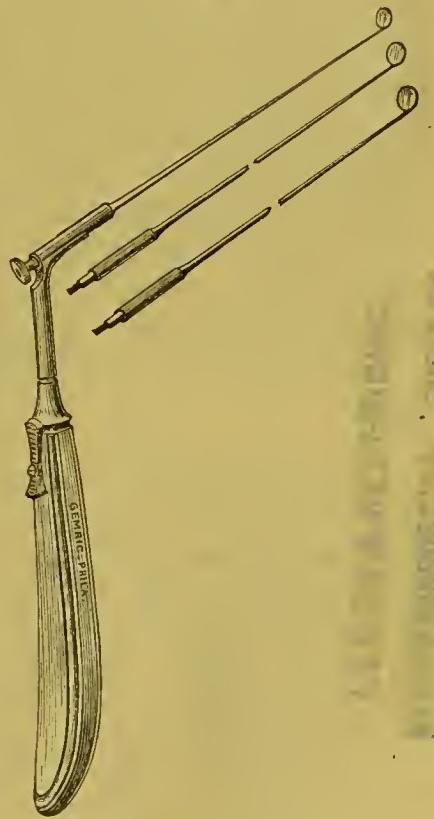
BLAKE'S MIDDLE-EAR MIRROR.

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[1] Transact. Amer. Otol. Soc., 1872.

Position of Patient's Body and Head.—As by far the most usual way of examining the ear is by reflected light, I shall suppose, in what follows, that reference is made entirely to that mode. The patient should sit with the ear turned from the source of light. He may lean back or sit high and straight in the chair, but the axis of his body should not be inclined either to the right or left. His head should be inclined somewhat towards the shoulder opposite to the ear to be examined. It is important for the comfort of the examiner that the body of the patient should not be inclined away from him, for if it be, then a great strain must come on the back of the surgeon in his endeavor to reach after the ear.

Position of Surgeon.—The surgeon standing alongside of the patient, in front of the ear to be looked into, should grasp the auricle at its upper and posterior margin, gently between the index and middle finger of his left hand, and pull the auricle a little upward and backward. This is always to be done by the left hand, no matter which ear is examined. This leaves the right hand free to hold the mirror. The patient should be placed, and the surgeon should stand so that the light may fall on the mirror slightly from the surgeon's right side, or directly from in front—never from the left in the above position of patient and examiner. These rules of position of light, patient, and physician are especially important when artificial light is used.

Insertion of Ear-speculum.—With the auricle grasped as directed above, between index and middle finger of the left hand, the speculum or ear-funnel may be gently inserted in a direction slightly downward, inward, and forward, or in general terms towards the patient's nose, by the other hand, and then grasped by the thumb and index of the left hand. Or it may be inserted by the thumb and index of the left hand at the same moment the index and middle fingers grasp the superior posterior margin of the auricle. In the latter instance a very gentle and slight rotation will be all that is sufficient to place the ear-funnel properly. The speculum being now in the meatus, light is to be reflected into it from the mirror.

The first point to be decided upon in making an examination of the ear is whether the auditory canal is entirely free from

obstruction or not.   If it is, then the eye of the observer should, after ascertaining the state of the wall of the canal, seek the membrana tympani.   The chief obstacle in such a search is usually the misdirection of the axis of the funnel.   This, instead of being made to correspond with the axis of the auditory canal, is directed most usually by the unskilled so as to fall on the sides of the canal or only partially on the drum-head.   Hence it is not at all uncommon to hear a diagnosis made for the membrana tympani, which is based entirely on a view of the condition of the skin lining the auditory canal.

What should be seen at the fundus of the canal is described on p. 47, yet it will be a long time before the eye can accommodate itself to the conditions of illumination in the external ear, so as to fully interpret what it sees.   The experienced eye is able to resolve into depressions, elevations, curves, etc., that which is projected entirely in the same plane by the beginner.

Removal of Obstacles to a View of the Membrana Tympani.—It requires but a small object, a few stiff hairs, or a flake of cerumen, or of epithelium, to obstruct the view of the drum-head.   All such are most easily removed by a few syringefuls of warm

Fig. 46.
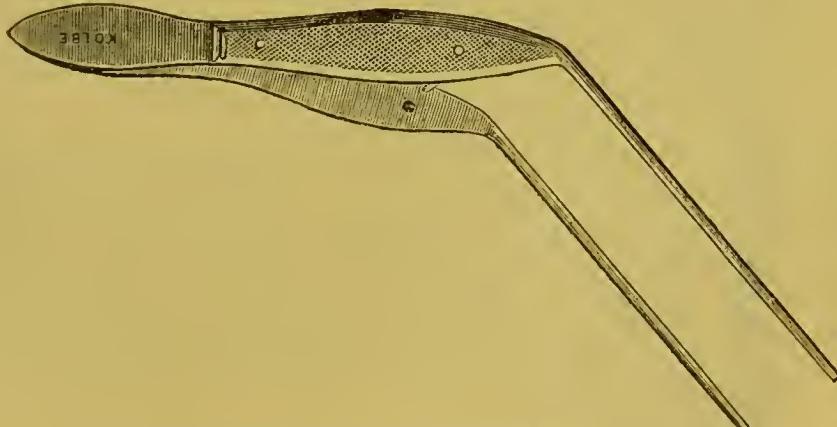
DELICATE FORCEPS FOR REMOVING FOREIGN BODIES FROM THE EAR.

water; this, however, will render the drum-head a little macerated, and hence deprive it of whatever lustre it may have had. This must be borne in mind in looking at the drum-head after warm water has been syringed upon it.   Therefore, when it is especially desirable that the amount of natural lustre in a given

case should be estimated, an obstructive substance might better be gently and most carefully lifted or wiped out of the canal. The former is most readily accomplished by the delicate forceps shown in Fig. 46, while the canal is thoroughly illuminated by the forehead mirror. If the obstruction to vision can be wiped or swabbed out, the cotton holder, with its little wad of cotton at the roughened end, will enable one to do this.

Fig. 47.

The Cotton Holder.—This is a most useful instrument, both for cleansing the ear and conveying medications to diseased surfaces in the organ. The shaft is made flexible for an inch or two, as indicated in the wood-cut, and roughened at the tip. At the latter point, a small tuft of cotton may be coiled, and then used, as already indicated, for cleansing, and for treating the ear. When the cotton is to be removed, it should be twisted off in a direction opposite to that in which it was wound about the end, and not submitted to a flame, as has been done, greatly to the detriment of the instrument.

During all these procedures for removing small obstructions to a good view of the drum-head, the canal is supposed to be most carefully lighted by light reflected from the forehead mirror, and the operations performed by a skilled hand.

If the methods suggested should be inadequate to remove obstacles in the auditory canal, recourse may be had to syringing. The syringe should be carefully chosen; one that holds two fluidounces will be large enough, though both larger and smaller ones may be used. The syringe should work perfectly, being neither too loose nor too tight in the piston. The model ear-syringe is one made by Leiter of Vienna, and shown in the wood-cut. (Fig. 48.) It holds two fluidounces, is made of fine brass throughout, excepting at its nozzle, where it is of hard rubber. A nozzle of such material is at once less cold to the ear, and less easily corroded by the various fluids syringed into and out of the ear; its shape, furthermore, renders it less likely

COTTON HOLDER.

Fig. 48.

to wound the meatus should the instrument slip or be pressed too firmly against the skin of the canal. To prevent slipping of the instrument, the two rings at the top of the barrel will be found of highest usefulness. But brass syringes of this kind are expensive in this country, and being rarely called for by physicians, nor ordered for their patients, are rarely found ready made in the shops. There is, however, an excellent syringe for aural purposes always at hand in the hard rubber, male syringe No. 2. This is not only very good, but reasonable in price, so that all patients, even the majority of those seen in the infirmary, can buy it. At this point it may be said unhesitatingly, that all forms of syringes sold in the drug stores and elsewhere, under the high-sounding name of " ear-syringes," are uniformly dear and as uniformly worthless.

There is one specially bad form of syringe sold under the name of ear-syringe. It is made of hard rubber; the chief, if not the only danger in this instrument, lies in its slender point about a half-inch in length, in which the otherwise harmless conical nozzle is made to terminate. This point, the patient is told by the ignorant vendor, to insert into his auditory canal. This done, the slightest turn, either of the head or of the handle, will drive the point against the sensitive canal and wound it. Such a syringe, with its elongated tip, could, in the shallow meatus of a child, *reach, and thus injure the membrana tympani.*

EAR SYRINGE AND OLIVE-SHAPED NOSE-PIECE, for syringing nares.

Basin and Towel.—In syringing the ear a towel should be laid over the shoulder, and brought up as high as, and turned in over, the collar of the patient.

The basin or cup for holding the water and catching the return current from the ear may be of various kinds and patterns. An ordinary kind is made of tin, the floor of which is kidney-

shaped. (Fig. 49.) Such a basin fits very closely under the ear against the neck. But tin soon rusts and becomes useless. If the basin be made of a more durable metal it becomes more costly, but no more easily kept clean. A finger bowl of glass or

Fig. 49.
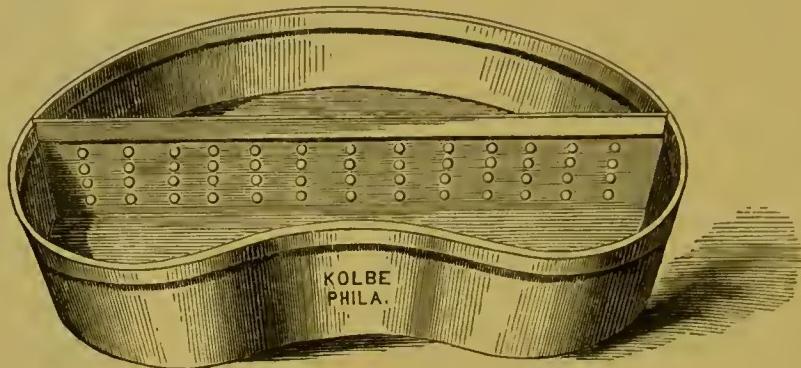
TIN BASIN USED IN SYRINGING THE EAR.

china is very good, because clean, cheap, and always at hand. A very simple, cheap, durable, and clean bowl may always be had by converting what is known in the china stores as a bird's bath tub, into a cup for holding water during syringing the ear. This little utensil has an oval bottom, the long diameter of which is 12 cm.; the short diameter 8 cm. The sides are 5 cm. high, and form an angle of about 95° with the base of the bowl.

Syringing the Ear.—In syringing the ear, cold water must never be used. Let the water used for syringing be pleasantly warm; some patients prefer it much warmer than others. Provided with a syringe as described, as well as with a receptacle for holding and catching the water, let the surgeon grasp the auricle between the thumb and forefinger of the left hand and pull it gently upward and backward. With the auricle thus held let the syringe be emptied slowly but firmly into the auditory meatus. Point the syringe downward and forward toward the patient's nose. The current from the syringe should be thrown along the upper wall of the auditory canal, thus permitting the return current to take place along the floor of the canal.

In some cases considerable force may be used in throwing the

current of water into the canal, as, for example, when it is desired to remove a foreign body from the fundus of the canal or when the canal is blocked up with a large and adherent wax-plug. I have found it decidedly advantageous to give to the syringe a gentle spiral motion as the current of water is going into the meatus. This impulse conveyed to the water will thoroughly wash off all adherent matters from the wall of the auditory canal.

Examination of the Nares and Fauces, Throat, and Eustachian Tube.—The inspection of the nares, fauces, and throat, and the examination of the state of the Eustachian tube by means of the Eustachian catheter, form perhaps the most important part of a complete aural examination.

This is specially true of the more chronic forms of ear-disease, for to the parts named the chief treatment must be directed. The inspection of the nares may be made either from behind or in front ; if in the former way, *i. e.* by posterior rhinoscopy, the ordinary laryngeal mirror may be used, and the light either of the brightest day or of a large argand burner may be thrown on the laryngeal mirror by means of reflection from a large forehead mirror.

Fig. 50.

TOBOLD'S APPARATUS.

This is at once convenient, inexpensive, and amply sufficient. If a more elaborate mode is desired, recourse may be had to the very elegant Tobold apparatus.

The former method, however, by means of the large forehead mirror and the argand burner, is vastly preferable for the ordinary examination of patients. It is the means used in the large clinics of Vienna, and the student, as well as the practitioner, with the forehead mirror once placed upon his head, may pass from one patient to another without the trouble and inconvenience which would attend transporting a cumbersome appa-

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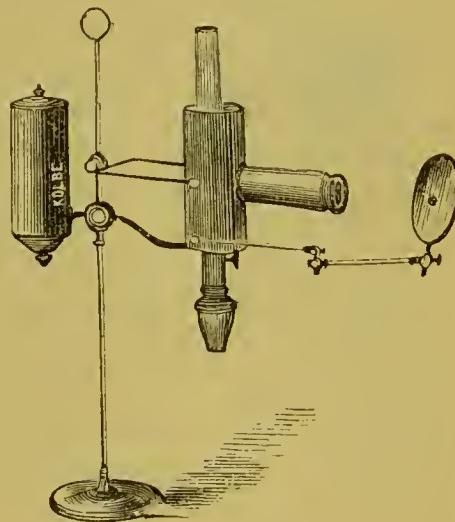
ratus. All that is needed is an argand burner or a bright flame of any kind, unless bright day-light is chosen. I would say, however, that in using the laryngoscopic mirrors, a bright artificial light in a darkened room is by far the best. Bright daylight is too diffuse, illuminating other parts, and not therefore bringing into bold relief the parts specially under examination. Direct sun-rays, on the other hand, are too powerful when collected and thrown by the mirror into the ear or throat. It is a very easy matter to burn the parts thus illuminated by concentrated sun-rays.

Forehead Mirror and small Laryngeal Mirrors.—The forehead mirror which is to be used in the above-named examination is

Fig. 51.

FOREHEAD MIRROR.

10½ cm. in diameter, and has a focal distance of about 30 cm. There is a small transparent spot at the centre, the glass being left unsilvered at that point. The metallic back which holds the mirror is bored at the centre so as to correspond with the central bare spot in the mirror. It is entirely unnecessary for purposes of inspection that the glass should be perforated at this point. Such a perforation adds nothing to the optical value of the mirror, but, as it endangers the glass, adds greatly to the cost. All the Vienna reflectors are now made unperforated, but unsilvered at the centre. The reflector should be provided at a point on the circumference with a small ball which fits into an adjustable socket on the plate of the forehead band. The eye of the examiner may look through the opening in the mirror, in which case it is of course directly in the focal line, or the mirror may be so placed as to permit the surgeon to look either under or to one side of it and yet gain good illumination.

The surgeon should provide himself with four sizes of laryngeal mirrors, two of each size entering into his set. One set should be marked and kept for examining specific or suspectedly specific cases, thus removing all danger of contagion from his more fortunate patients. No. 1 should be 1.50 cm. in

diameter; Nos. 2, 3, and 4, respectively 1.75, 2, and 2.50 cm. in diameter. These should be fixed at an angle of 40°, to a slender but perfectly stiff shaft 12 cm. long, which is made to slide into a handle 10 cm. long, made of wood, bone, hard rubber, etc., bored its entire length. Into this hollowed handle the shaft of the mirror may be slipped and clamped at any point by a small lateral screw.

Thus provided with the three factors of examination, a bright flame, a forehead reflector, and a laryngeal mirror, let the surgeon place the patient on a chair close in front of the light, so that the latter shall come over the left shoulder of the patient. In this position the light will come towards the surgeon from his right, and somewhat from above if the lamp used is of ordinary height. If the larynx is to be looked at, the patient's head may be thrown very slightly backward, his mouth being open. The tongue may be depressed either by the surgeon or by the patient. In many cases all that is necessary in order to get the tongue out of the way is to have its tip seized between the index finger and the thumb of the patient's right hand and drawn outward. To render it less likely to slip from his grasp, the tip should be held between a fold of the edge of a towel or napkin. The laryngeal mirror should then be held for a moment with its glass surface, not its metallic back, over the flame in order to prevent the condensation of the breath on its surface. By holding the glass surface over the flame, not only is the mirror heated more quickly, but its silvered surface is thus kept from melting, for less heat is acquired in this way than if the mirror were heated by subjecting its back to the flame. This rule holds good for all cases in which the laryngeal mirror is to be used, whether for laryngoscopy or rhinoscopy.

In viewing the larynx the mirror should be introduced with the shaft on either side of the patient's mouth, rather than in the median line. Then, while the patient phonates the vowel sound *aa*, a view may be gained of the image of the laryngeal opening, in the small mirror held over the glottis. For all further explanation of laryngoscopy the reader is referred to works on that subject.

Rhinoscopy and Rhinoscopic Examination of the Mouth of the Eustachian Tube.—Rhinoscopy, though by no means indispensable to the aurist, becomes of far more value than laryngoscopy, on

account of the view he may gain of the faucial end of the Eustachian tube by the rhinoscopic method. The instruments employed are similar to those described above, but the method of introducing the mirror is somewhat different. The patient's head should not be thrown backward; it must be upright or in some cases perhaps a little thrown forward. In rhinoscopy the tongue may be depressed by the examiner, but never by the patient. Here the mirror must usually play the part of the tongue depressor, though the latter may often be used with advantage. With the patient's mouth wide open and his tongue lying perfectly naturally within the limits of the teeth, let him try to breathe through the nose. Then, with the shaft of the mirror lying in the median line of the tongue, pass the former slowly toward the velum and behind it, pressing the tongue down as firmly as the patient will permit. Usually all endeavors at getting a view of the posterior nares and vicinity fail most signally at first. This of course is due to the involuntary rising of the tongue and the consequent instability of the mirror, to which must be added the blurring of the mirror by the touching of its surface by the uvula.

After a few visits or even after repeated trials in some cases at the first visit, the tongue is more easily depressed, the patient gets more used to feeling the mirror in his fauces, and then a view may be gained of the posterior nares and the faucial extremity of the Eustachian tube.

There are, however, individuals in whom the velum is placed so near the posterior wall of the pharynx as to preclude any rhinoscopic examination. The surgeon soon learns to recognize these, and is wise in making no attempts at examining them with the rhinoscope.

Eustachian Catheters.—The ocular examination of the Eustachian tube ceases with the rhinoscopic view of the faucial extremity; beyond that point the examination becomes entirely aural, by means of the Eustachian catheter and the auscultation tube. The Eustachian catheter consists of a tube of metal or hard rubber, curved at the beak as seen in Fig. 52. The conical handle must be made so as to permit the end of the air-bag to fit accurately into it, and the ring upon the handle should be firmly attached to each instrument in the same plane with the

Fig. 52.
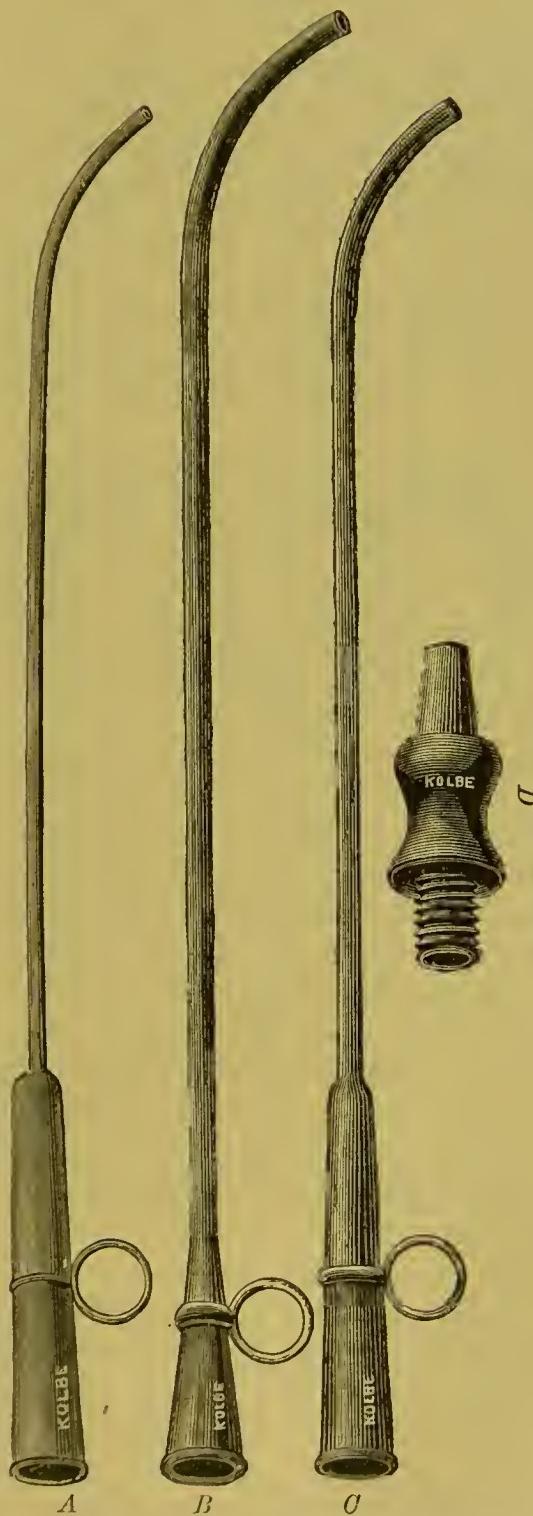
EUSTACHIAN CATHETERS OF HARD RUBBER.—Three sizes, *A*, *B*, and *C*. *D*. Hard rubber tip of the air-bag, made to fit accurately into the large end of all catheters on the principle of the ground joint.

circle of which the curved beak is an arc. By observing the position of the ring-indicator, one can always know the precise position of the beak of the catheter. Another important though perhaps fortuitous use of this ring is to hold a ticket with the name of the patient using the catheter. Every aurist should have a large number of all sizes of these catheters, so that each patient may have one to himself, and thus escape the danger of contagion.

Instead of the ticket each patient may have a long and slender paper box in which the catheter may be kept; but the importance of isolation of patients in this particular cannot be too strongly urged.

Not only has secondary syphilis been communicated by using the same catheter for all patients,[1] but catarrh, not dependent upon such a specific poison, may also be thus communicated.

Since it will be necessary to have catheters of different sizes, the diameter should vary from 1 to 3 mm., the size with a diameter of 2 mm. being the one most used, as it is best adapted to introduction into nostrils of average width. The hard rubber catheter has the advantage of lightness and cheapness, and of not being easily corroded. Its cheapness renders it easier for the aurist to supply himself with a number of such instruments of all diameters. On the other hand, a virgin silver catheter is very flexible, and any need to change the curve of the beak is thus easily met in one instrument. But to have dozens of such instruments becomes expensive for the surgeon, though of course incumbent upon him if each patient is to have his own instrument.
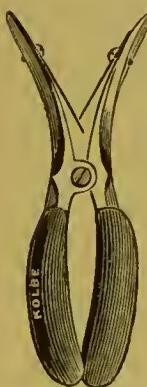
Fig. 53.

BONNAFONT'S
NOSE-CLAMP.

The catheter may be held in position in the nostril by means of Bonnafont's nose clamp.

The Auscultation Tube.—This instrument is the highly important adjuvant of the Eustachian catheter; in fact, in so far as the latter is of aid in an objective examination, it owes that power to the auscultation tube. The therapeutic effects of the use

[1] A celebrated occurrence in Paris, by which a number of people, including some of highest position, were inoculated.

of the Eustachian catheter are, of course, entirely independent of the auscultation tube. The latter consists of a yard of rubber tubing, 8 mm. in its outside diameter. Black rubber tubing is preferable, being more lasting and less sulphurous in odor than the ordinary domestic white rubber tubing. Upon one end of this tube there should be a white bone end-piece made to fit the surgeon's own ear; at the other end there should be a black end-piece, for the patient's meatus. In using the auscultation tube, one end should rest snugly in the meatus of the ear catheterized, while the other end must rest equally well, though not too tightly, in the examiner's ear.

Fig. 54.
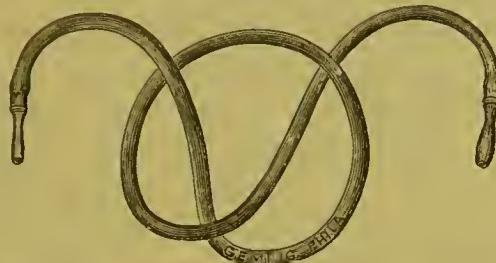
AUSCULTATION TUBE.—Black end for patient's, white for surgeon's, ear.

Let it be supposed, for example, that the patient's left ear is to be catheterized, and that the auscultation tube is also to be used. Let the examiner place his end of the auscultation tube in his left ear, bring the tube loosely around behind his neck and over his right shoulder, placing the other end of the tube in the patient's left ear. If the tube be thus supported it is less in the way of the surgeon, and less likely to fall either out of his or the patient's ear.

The usual method given in most works on aural surgery, is to allow one end to rest, for instance, in the patient's left ear, while the other end is resting in the surgeon's right ear. In such a case, not only will the tube hang down between the patient and surgeon and be in the way, but the mere weight of the auscultation tube when thus suspended is sufficient to drag it out of place.

The Air-bag or Hand-balloon.—The general appearance of the hand-balloon is given further on, in the figure of Politzer's apparatus. The use of this bag is to force air through the catheter into

the Eustachian tube and tympanic cavity. It is of the greatest importance that the end-piece at the point of the balloon-like bag should fit accurately into the catheter, and, like it, be of hard rubber, Fig. 52, *D*. This hand air-bag is of the greatest importance and usefulness, for with it not only air, but medicated solutions may be forced through the catheter and into the Eustachian tube. It is very uncommon that more impelling force is needed in catheterization of the Eustachian tube than can be exerted by means of the hand as it squeezes the air from this bag. During the expulsion of the air from the bag great care should be taken not to force the axis of the bag out of line with that of the catheter, for, if this should occur, either by an upward or downward movement of the hand and wrist, the catheter if of hard rubber will be very apt to break, if of silver, to bend. In compressing the air-bag, no motion should occur, except in the fingers of the right hand or the hand employed in compressing the bag. A little practice will enable the operator to make only such a motion with the fingers, though at first there is an almost involuntary tendency to flex the hand laterally on the wrist towards the ulna, at the same moment the fingers are made to squeeze the bag. If the bottom of the bag is made to rest on the palm of the hand while the fingers surround the sides, this tendency to lateral motion will be removed.

Catheterization of the Eustachian Tube.—Provided with the three instruments described in the preceding pages, viz., a catheter, an auscultation tube, and a hand air-bag, the surgeon may endeavor to catheterize the Eustachian tube, *i. e.* he may endeavor to place the beak of the Eustachian catheter in the faucial end of the Eustachian tube, so as to enable him to force air into the latter, and if that be patulous, the air may pass into the tympanic cavity.

In catheterizing the Eustachian tube, the patient may sit or stand at the surgeon's option ; as a rule, it will be more desirable for the patient to sit, since it is more comfortable for him, and will hence enable him to hold still much better. Let the patient, then, sit down with the hips well back in the chair, and his spinal column and head erect. The latter may be braced against the wall or the back of the chair, should the latter come above the

patient's head.   Then, with the auscultation tube adjusted as
described, the surgeon should place the fore and middle fingers
of his left hand on the patient's forehead a little above the root
of the nose, and with his thumb he should lift up the tip of
the patient's nose and hold it up until the catheter is well
inserted.

Fig. 55.
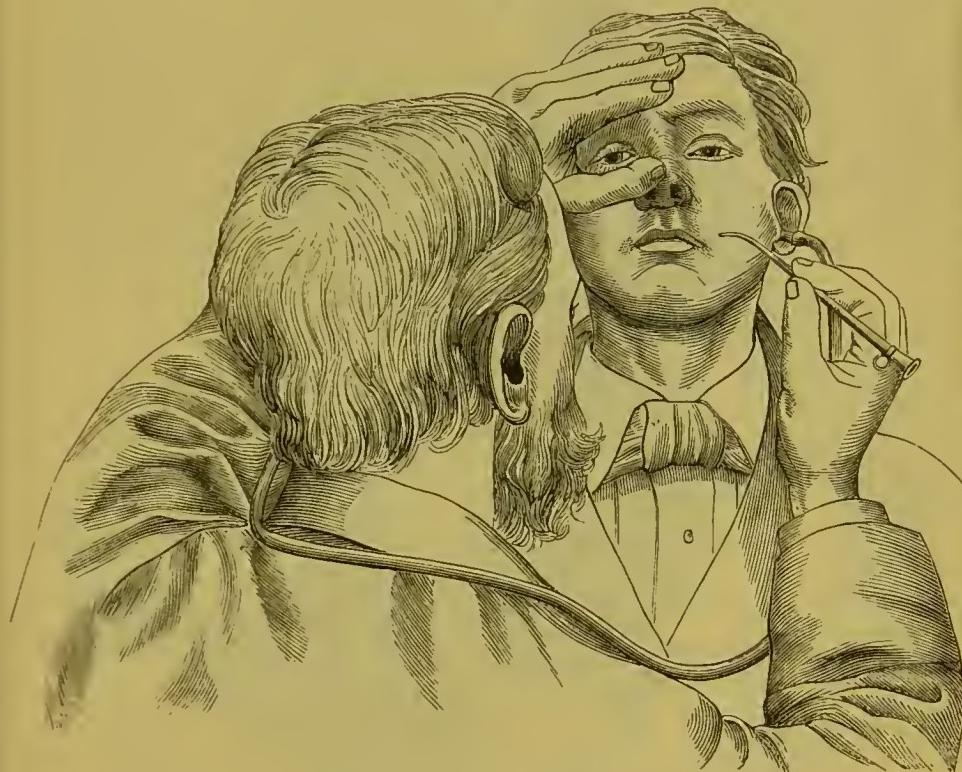
INSERTION OF THE EUSTACHIAN CATHETER.

With the tip of the patient's nose held up as just described,
let the surgeon grasp the catheter as he would a penholder,
between the thumb and forefinger of the right hand, holding
his hand down about as low as the patient's chin, towards
which the palm of the catheter-hand should be turned.   Now
insert the beak of the catheter into the nostril corresponding to
the ear to be catheterized, and with a compound upward and
forward motion carry the instrument along the floor of the
nose until the beak reaches the nasopharynx and at last touches
the posterior pharyngeal wall.   The ring should point directly
downward upon the arrival of the beak of the catheter in the
nasopharynx.

With the catheter's beak in the position above named, viz., at the posterior pharyngeal wall, the beak may be turned outward toward the ear to be catheterized. By this motion the beak will slip into the fossa of Rosenmüller. The mistake

Fig. 56.
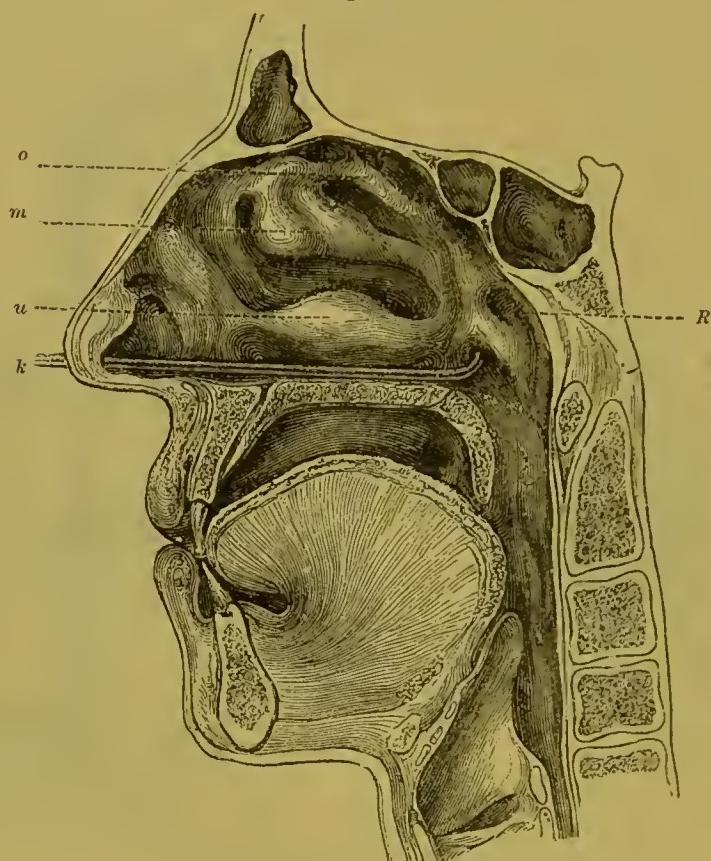
INNER VIEW OF THE RIGHT HALF OF THE HEAD; ANTERO-POSTERIOR SECTION. (Gruber.)— o. Superior turbinated bone. m. Middle turbinated bone. u. Inferior turbinated bone. R. Rosenmüller's fossa, bounded in front by the cartilaginous lip of the tube; in front of the latter the pharyngeal opening of the Eustachian tube, in which the catheter k is placed.

is usually made at this point, in supposing the catheter's beak rests in the mouth of the Eustachian tube, and unsuccessful attempts at inflation may be made. But in order to place the beak in the mouth of the tube, the following manipulation becomes necessary. After the beak of the catheter has been turned into the fossa of Rosenmüller, draw the catheter forward, letting the beak slip over the posterior lip of the Eustachian tube, and as soon as this is done turn the catheter so that the ring-indicator will point towards the ear catheterized, at an

angle of 45°; at the moment this movement is made with the catheter, its beak slips into the faucial extremity of the Eustachian tube. Of course, this is easily said, less easily done; but with a little practice the touch is soon educated, and the Eustachian catheter can be inserted into the mouth of the tube with great ease.

Fixation of the Eustachian Catheter.—After the catheter has been thus put in place, let the thumb and forefinger of the left hand grasp the instrument close to the nose, while the remaining three fingers are braced above the root of the patient's nose, at the point formerly occupied by the middle and index fingers, during the elevation of the tip of the nose by the left thumb, and the insertion of the catheter by the right hand.

Fig. 57.
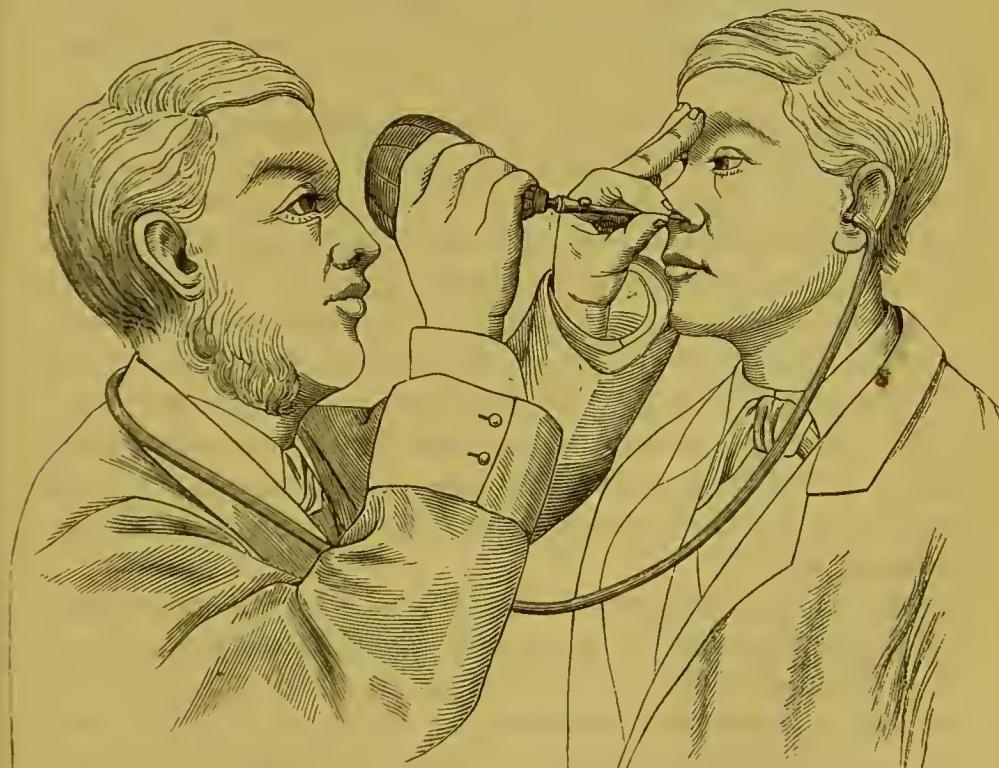
FIXATION OF THE EUSTACHIAN CATHETER IN POSITION, PREPARATORY TO INFLATION.

With the catheter thus fixed in position, and the auscultation tube passing from the patient's ear to the ear of the examiner, the latter may grasp the hand air-bag and make inflations into the tube and tympanum. If the Eustachian tube is pervious,

air will be heard to enter it with more or less force. As a rule, two or three inflations with the contents of the air-bag will be sufficient, both in force and in number, to properly and safely ventilate the middle ear. When considerable stimulation is demanded by the atonic condition of the muscles and mucous membrane, numerous inflations, even as many as a dozen, may be made with entire safety. In using the Eustachian catheter, the only danger is from emphysema; but this can never occur unless the mucous membrane has been abraded by the unskilful introduction of the catheter. Even should such abrasion occur, emphysema might not be produced unless very powerful inflations were to follow. The two fatal cases which occurred, during inflation, in the practice of a well-known London quack, were caused, probably, by the use of a powerful air-pump; but air-pumps are no longer used, or at least very rarely, by responsible men. There is certainly no record of a case of death from emphysema resulting from gentle inflation made by the hand air-bag.

Where death has occurred from emphysema of the pharynx and the parts about the larynx, the fatal result has most probably been brought about just as it is in œdema of the glottis. The treatment, therefore, should have been the same and just as prompt in the former as in the latter malady, i. e. a free scarification of the puffed-up parts in order to permit the air to escape from the cellular tissue beneath the mucous membrane. As the Eustachian catheter is in constant use all over the world, and as the only cases of death which were ever suspected of being caused by its use occurred at the hands of a quack, the latter, and not the instrument, should be held accountable for the unfortunate result.

Voltolini[1] has demonstrated how ephysema may be produced by the improper use of the catheter, and how death may occur when the introduction of air producing the emphysema is very powerful. After the introduction of a probe or bougie into the Eustachian tube, the mucous membrane is probably somewhat lacerated, and therefore no air should be forced in immediately after probing. Hence, the air-pump and all means of inflation more powerful than the hand air-bag should be discarded.

[1] Ueber das Emphysem bei der Luftdouche in das Mittelohr, M. f. O., vii. No. 1.

Death in cases of emphysema produced in the above way might be due to pneumothorax. Voltolini proved this to be the cause of death in a dog, into the naso-pharyngeal region of which he first introduced a catheter, then a wire, by which he wounded the mucous membrane of the parts near the opening of the Eustachian tube. By a powerful introduction of air he produced sudden death, and a post-mortem examination of the animal showed that air had entered the pleural sac and produced collapse of the lungs. There was no emphysema of the vocal cords nor of the larynx.

Other Methods of Catheterization.—Prof. Gruber recommends a somewhat different method from the foregoing. Thus, after the catheter has been introduced through the nose and has reached the hinder wall of the pharynx, let the instrument be drawn straight outward until its curved beak lies against the soft palate. Then push the catheter a short distance (from half an inch to an inch) inward, and turn the beak outward towards the ear. It will be found that as a rule the beak will slip into the mouth of the Eustachian tube. A somewhat less complicated method is that known as Löwenberg's. In this method the catheter is introduced in the usual way through the nose until it reaches the posterior wall of the pharynx. Then let it be turned inward and drawn forward until the curve of its beak touches the septum narium. If now with a downward turn the point of the catheter be made to describe a semicircle, the beak will usually slip into the mouth of the Eustachian tube. All of the above efforts at insertion of the point of the catheter into the mouth of the Eustachian tube, as well as inflation, may be greatly helped by an act of swallowing on the part of the patient at the precise moment the instrument is to be inserted into the mouth of the tube, or just as the air-bag is emptied through the catheter.

Dr. H. D. Noyes,[1] in order to obtain a catheter to be introduced into the Eustachian tube from the opposite nostril, gives the beak of an ordinary catheter, of rather more than the average length, a double curve. The elongated beak generally used in such cases, at three-eighths of an inch from the point, is bent " in a plane transverse to the plane of the primary curve."

[1] Transactions of the American Otol. Soc., vol. i. p. 111, 1870.

Politzer's Air-bag and Method of Inflation of the Eustachian Tube and Tympanic Cavity.—Prof. Adam Politzer has given to the profession a most valuable means of inflating the naso-pharynx, Eustachian tubes, and tympana. The instrument bears his name, being known as Politzer's air-bag, and the method of its employment is known as Politzer's method of inflation. The instrument consists chiefly of an ordinary air-bag such as is used for forcing air through the Eustachian catheter. Instead of the conical tip of the ordinary hand air-bag, the instrument devised by Politzer is supplied with a somewhat bulbous tip, to which is attached a piece of black rubber tube 8 cm. long, which forms the pliable connection between the air-bag and the nose-piece.

Fig. 58.
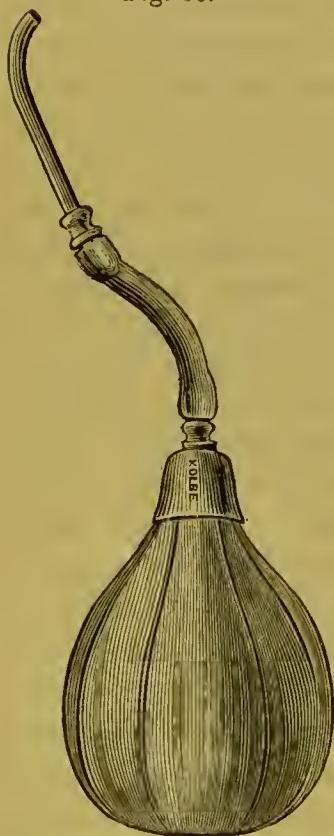
POLITZER'S AIR-BAG FOR IN-
FLATING THE MIDDLE EAR.—(One-
third natural size.)

The latter piece is made of hard rubber, and varies from 3 to 4 mm. in diameter. It is curved slightly at the beak and resembles at this point a coarse Eustachian catheter. In fact one may extemporize a Politzer's apparatus by attaching an ordinary hard rubber catheter to the hand air-bag. But in this case the disadvantage is in the stiffness of the catheter and its great liability to snap in half.

Politzer's method of inflation depends upon the physiological fact that, at the moment of swallowing, the velum palati rises and thereby draws the anterior wall of the Eustachian tube from the posterior. At this moment the faucial extremity of the tube is so patulous that air forced through the nares, not being able to pass downward into the fauces and mouth, because the velum palati prevents it, will by following the course of least resistance pass into the tube and usually into the tympanum.

In order to accomplish this result at the desired moment, the patient is instructed to take a sip of water and retain it in his mouth until told to swallow. After

the water has been thus taken, let the surgeon place the curved nose-piece into either nostril and compress the nostril in front of the nose-piece.   The usual error is made of trying to compress the ala of the nostril down upon the nose-piece.   This is not only very painful to the patient, but defeating to the surgeon. The index finger should compress the other nostril so that no air from the bag shall escape outward through the nose.   The point of the nose-piece should be directed outward against the ala, rather than inward against the bony septum.   If the latter is done, and it usually is the mistake of beginners, the septum will be painfully pressed if not wounded, and bleeding from the nose may be the very undesirable result.

In using this method of inflation one ear of the patient may be connected by the auscultation tube to the ear of the surgeon ; but this is by no means necessary, since, as a rule, when the method is properly carried out, a peculiar gulping sound is produced which the surgeon soon learns to recognize.

By the very nature of the physiological process called to aid in Politzer's method of inflation, both ears are likely to be inflated at the same time.   The fact that one ear cannot be isolated during this mode of inflation should be borne in mind, if for any reason such isolation on the part of either ear should be demanded.   In such a case the tube demanding inflation must be catheterized.   The force of the Politzer inflation, however, can in any case be augmented on either side by pressing the finger firmly into the canal of the ear opposite to the one it is specially desired to ventilate.   By some, it is supposed that this latter modification is aided by holding the head over towards the shoulder opposite to the ear which is to receive the greater amount of inflation.   As in such a position the ear on the up-turned side is highest, it is to be supposed that the air may take its course more readily toward that ear than the one turned downward and firmly stopped by the finger.

Respecting the method of inflation during phonation, instead of during swallowing, as lately suggested by Profs. Lucæ and Gruber, I would say that in some cases I have succeeded in inflating the ears by following their suggestions, but I am equally sure that it is neither as powerful nor as certain as Politzer's method.   In very young or unreasonable children who cannot or

will not swallow, but do cry, Politzer's method is invaluable, for, as he taught long ago, the more the child cries the more firmly does it lift up the velum palati and favor the surgeon's attempts at inflation of the tympana.

CHAPTER II.

SOUND, HEARING, AND TESTS OF THE LATTER.

Sound is motion imparted to the auditory nerve by undulations in the air. A shock from a vibrating body, conveyed to the air immediately surrounding it, is propagated by a wave of undulation, not of progression, to other particles of air. This wave of sound at last reaches the membrana tympani, and transmits itself, by the aid of the latter and the ossicles of hearing, to the fluid of the labyrinth and to the nerve of hearing.

Hearing is the perception of such sonorous undulations of the air. It implies a free access of air to the drum-head, a perfect oscillation to and fro of the chain of ossicles, unimpeded movement of the stapes in and out of the oval window, and a normal percipient organ in the labyrinth. If any of these requirements is wanting, the hearing will be defective, the degree varying from "hardness of hearing" to total deafness. The vibrations in the air may be periodic or irregular, *i. e.* they may be of equal length and duration, or they may be unequal and crowded upon each other in the greatest confusion. The former would produce musical sounds or *tones*, and the latter, *noises*.

Intensity, Pitch, and Quality.—Frequent allusion is made in acoustics to the intensity, pitch, and quality of sounds. The first depends on the breadth or amplitude of the vibration. When a wire is first set in vibration, the extent of the excursion it makes, backward and forward between its fixed ends, is visibly much wider than it is as it gradually ceases to vibrate. During these wide excursions the sound is strongest, but it grows weaker as the vibrations become narrower. It must,

however, be kept in mind that only the width, not the number of vibrations, has diminished, and therefore the pitch of the note remains the same, though weaker.

Pitch depends simply upon the number of vibrations emanating from a sounding body in a second, thus a high pitch means numerous vibrations in a second, low pitch implies but few.

Quality or Clang-tint.—The quality of a sound, also called its clang-tint or timbre, depends upon the peculiar kind of vibrations and the manner of their occurrence. The difference between one musical quality and another depends entirely on the presence and the strength of the partial or over-tones.

Partial or Over-tones.—If a wire be stretched between two points, it can be made to vibrate as a whole, or it can be made to divide itself into a number of equal parts. The note emitted by the wire when vibrating as a whole is called its fundamental note. The notes represented by the vibrating subdivisions of the wire are termed its partial, secondary, or over-tones. All vibrating bodies or instruments, therefore, give out, besides their fundamental notes, their over-tones, or harmonics, as they are also termed, and it is the general admixture of these, with their varying number and strength, which goes to form the quality peculiar to a given sound. This is called timbre by the French, and Klangfarbe (clang-tint) by the Germans.

System of indicating Musical Notes by Letters.—In otology, frequent reference is made to musical notes. This is generally done by citing the letter used by the Germans to designate a particular note. This is a system whereby the position of a note in the scale, and hence the number of its vibrations in a second, are very easily shown. It is accomplished by using different letters for the notes in an octave, and different kinds of type, or adding co-efficient numerals to the same type, to indicate the octave to which the notes belong. As it is of the greatest importance that the reader should know at a glance the relative position in the musical scale of the notes thus cited, in the examination of the ear and in recording the hearing, the

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following table, as found in Prof. Helmholtz's celebrated work,[1] is here given.

	$C_i–H_i$	C–H	c–h	$c^l–h^l$	$c^{ll}–h^{ll}$	$c^{lll}–h^{lll}$	$c^{lv}–h^{lv}$
C.	33	66	132	264	528	1056	2112
D.	37.125	74.25	148.5	297	594	1188	2376
E.	41.25	82.5	165	330	660	1320	2640
F.	44	88	176	352	704	1408	2816
G.	49.5	99	198	396	792	1584	3168
A.	55	110	220	440	880	1760	3520
H.	61.875	123.75	247.5	495	990	1980	3960

The letters at the top of the column indicate the note and the octave in which it lies ; the numerals, the number of its vibrations per second.

According to Prof. Helmholtz, the deepest note used in orchestral music is one of $41\frac{3}{4}$ vibrations in a second. In pianos and organs the lowest note is generally one of 33 vibrations per second, but some grand pianos are constructed to give out a note as low as $27\frac{1}{2}$ vibrations. The musical character of such low notes is very imperfect, especially those lower than E, with 41.25 v. s. They become musically useful only when sounded with their octave higher. Some pianos are made to give out notes as high as $a^{lv}–e^v$, i. e. from 3520–4224 vibrations in a second. The highest note used in orchestras is the d^v of 4752 vibrations, produced by the piccolo, a kind of flute. Beyond these limits the notes become shrill, disagreeable, and to some ears, absolutely painful.

By the same authority it is held that, only those notes lying between 40 and 4000 vibrations in a second, or within seven octaves, are of real musical value. Yet those lying between 20 and 38,000 vibrations a second, or within eleven octaves, may be perceived as musical notes. In this respect, the ear is far superior to the eye, for the latter rarely perceives vibrations of light extending much over an octave.

The so-called "Deaf Points" of the Ear.—Dr. V. Urbantschitseh[2] has pointed out a phenomenon heretofore undescribed, connected with the organ of hearing. He has shown there are some points near the ear, at which a vibrating tuning-fork cannot be heard, and he calls these "deaf points." By following his directions any one can verify his experiments. Thus if a tuning-fork held

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[1] "Die Lehre von den Tonempfindungen," Braunschweig, 1870.
[2] Centralblatt f. d. Med. Wissensch., No. 8, 1872, M. f. O. No. 2, 1872.

perpendicularly in front of the ear be started from the lower edge of the zygoma and moved backward towards the occiput so that the upper end of the fork passes the lower end of the tragus, two points will be reached where, though the vibrations of the fork are felt by the fingers, the ear will for a moment perceive no sound, until this deaf point is passed. The fork is then heard for a short interval until it reaches the second deaf point, after which the vibrations are heard once more as the fork is gently passed on its way backward towards the occiput. The same points are perceived if the vibrating fork is passed in the opposite direction, *i. e.* from behind forwards in the line above described.

The position of the first point is at the lower end of the tragus; the second, is at a point where the helix intersects the line of motion given above. If a tuning-fork held horizontally be passed vertically upwards before the ear, the same kind of deaf point is found in the region of the crista helicis. This phenomenon remains the same whether the tuning-fork is passed in the same line, at a greater or less distance from the ear. A further investigation led to the discovery of so-called " deaf fields" in the form of two small triangles, the first of which lies in front and above, the other behind and above. The apex of the anterior triangle lies at the lower end of the tragus, already spoken of, from which point the sides diverge gradually towards the frontal and parietal bones. The general tendency of these lines is upward; at the frontal protuberance they are 2–3 cm. apart. The apex of the second triangle is at the lobule of the auricle or near the lower part of the helix. The sides diverge in the direction of the lateral surface of the parietal and occipital bones. At a point corresponding to the uppermost part of the helix they are about 2–3 cm. apart.

Dr. Emil Berthold,[1] of Königsberg explains these phenomena as entirely unconnected with the physiology of the ear, but entirely due to the interference of the vibrations of the fork. Thus if a vibrating tuning-fork is moved slowly past the mouth of a bottle, the fundamental note of which corresponds to that of the fork, the air in the bottle will be set into consonance with the note of the fork excepting at the moment when the sound

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[1] Monatsschrift f. Ohrenheilkunde, No. 5, 1872.

waves entering the mouth of the bottle are quenched by inter-
ference. This will happen, says Dr. Berthold, when the first
tine of the fork has just past the inner edge of the bottle, and
again when the second tine has almost reached the inner edge
of the bottle, *i. e.* at two points which correspond to the tragus
and the helix.

Sound and Color.—Dr. J. A. Nussbaumer,[1] of Vienna, has
communicated some very interesting facts relating to subjective
perception of color produced in himself and in his brother by
objective perception of sound; but the same sound produces
different impression of color in each. The note "small e" on
the piano produces in the former the subjective perception of
the color of dark yellow; in the latter the impression of dark
blue. There are some colors which no note even calls up; blue,
yellow, brown, and violet are most frequently produced. There
is no red nor green, nor perfectly black and white in any notes.
Dr. Nussbaumer, however, perceived green once, upon hearing
suddenly a peculiar noise. Colors are also perceived by him in
dreams if noises are dreamt of.

The author endeavored to represent the subjective tint of the
fundamental note as a mixture of single tints corresponding to
the separate partial tones, and he was in a measure successful.

TESTS FOR HEARING.

Aerial and Bone Conduction of Sound.—Sound is conveyed to
the nerve of hearing in two ways: by the air and by the bones
of the head.

The first, aerial conduction, is the chief means of normal
hearing. The second may be very great in the normal organ in
the young. In old age, however, it is blunted.

The sound-conducting apparatus of the ear is adapted to aerial
conduction of sound.

Bone conduction of sound comes into consideration chiefly
as a test, respecting the condition of the nerve and the remain-
ing power of the sound-conducting apparatus in disease of the
ear.

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[1] Ueber subjective Farbenempfindungen die durch objective Gehörempfin-
dung erzeugt werden, Wiener Med. Wochensehr., Nos. 1, 2, 3, 1873.

· If the nerve or the conducting apparatus of the ear, *i. e.* the external auditory canal and middle ear, are affected, bone conduction of sound is soon impeded and manifests itself in such a way as to be of use in diagnosis.

Normal Hearing.—No precise standard of normal hearing has ever been defined. The normal ear hears all sounds that fall on it ; but it cannot be said, *à priori*, where good hearing ceases and defective hearing begins, for in many senses these are relative terms.

The sense of hearing must be regarded as composite, *i. e.* it consists in the ability to hear a number of different sounds both periodic and irregular in their vibrations. Such sounds can be heard singly or together. Hence, the sense of hearing may be said to lie in a collection of nervous elements, which can be aroused separately or together. The latter is shown by the well-known fact that more than one sound can be heard at the same time.

The Watch.—Some form of watch-work or ticking apparatus is an old and ready means of testing the hearing. In this way the pocket watch, mantel clock, metronome, or an especially contrived ticking machine has been called into requisition. But the watch being a low form of musical instrument according to Oscar Wolf,[1] which at best gives forth only two poor notes, not easily determinable in pitch, it can never have a wide application as a test. When using a watch as a means of determining the hearing, the test is being accomplished with only one or at most two notes. Now if the nerve fibres in the perceptive auditory apparatus, which were destined to perceive the notes given out by the test, happen to be the affected ones in a given case, then the watch will not be heard or but imperfectly, whereas a watch, the notes of which are of a different pitch, might be heard. Hence it is that the watch as a test so often fails.

Its inferiority as a test depends therefore on the fact that in using it the power of the ear to perceive only two notes of the entire musical scale, is placed on trial. But as far it goes, the watch may be of value as a test, especially if its notes be made

[1] Archives of Oph. and Otol., vol. iv.

to come out with intensity and if also the form known as a stop-watch be used.

The simplest and most convenient form of watch-test is the ordinary pocket timepiece. When using it as a means of testing the hearing, the watch should be brought from a point where it is not heard, gradually towards the ear, until the ticking is perceived by the patient, or until positive inability to hear it, even on contact with the head, is discovered.

The distance at which the watch used is heard by the normal ear should be known by the examiner. This distance may represent the *denominator* of a fractional form of expressing the hearing power: the numerator, the distance heard in a given case.

This is a suggestion of Dr. J. S. Prout, of Brooklyn, and a most valuable one it is. Thus a watch is heard by the normal ear 60 inches, and by a diseased ear in a given case 20 inches. The record in such a case would be expressed by the fractional formula $\frac{20}{60}$ in.

Dr. Roosa employs this formula with modifications, as, when the watch is heard only on contact, then $\frac{C}{60 \text{ in.}}$ would express this condition. $\frac{P}{60 \text{ in.}}$ and $\frac{O}{60 \text{ in.}}$ wound express respectively that a given watch is heard only on pressure or not at all.

It is not intended that these fractional expressions should be reduced, for in that case it would be less awkward to say instead of $\frac{20}{60}$, $\frac{1}{3}$. The idea is to let the fraction stand as above, so that the denominator shall show at a glance the exact distance the watch is heard by the normal ear.

A somewhat less simple method is given by Dr. Knapp;[1] thus, if a watch normally heard 10 feet be heard only 3 inches, then the hearing may be recorded as $\frac{3}{12.10} = \frac{1}{40}$ of the normal standard. Fractions of an inch are placed, in this method, either in the numerator, as H $\frac{1:2}{12.10}$, or the unit is to be left

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[1] Archives of Oph. and Otol., vol. iii. Part I. p. 220.

in the numerator and all other numbers in the denominators, as $\dfrac{1}{2.\,12.\,10}$, which shows the watch is heard at half an inch.

In order to avoid a mathematical operation I have found it useful to express the formula perhaps a little more arbitrarily, thus $\dfrac{\frac{1}{2}\ \text{in.}}{60\ \text{in.}}$ which shows that the watch of 60 in. is heard only $\frac{1}{2}$ in. Thus the original idea is fully maintained, and the record can be kept by the least mathematical.

The Stop-watch.—Of all forms of watch-work for testing the hearing the most useful is the stop-watch. Besides its power as a test, there is also in it the means of finding out whether the patient really hears the sound of the watch, or whether he *thinks* he does because he knows a watch is being held before his ear. This means is often the first to declare that the patient's statements respecting his subjective impressions of sound are unreliable.

If the ticking of the watch can be alternately stopped and set going at the will of the surgeon, errors of observation on the part of the patient may be detected. The same end has been gained by alternately holding and removing a diaphragm of paper between the ear and the watch.

Children, as a rule, give erroneous statements as to their ability to hear a watch. The reliability of their statements can soon be decided if a stop-watch be used, for they are obliged then to show whether they are aware of the stopping and the going on of the apparatus. A stop-watch for this purpose may be constructed to tick with great intensity. The form I have used for some years can be heard sixty feet by the normal ear, in the open air.

In some cases even while the ticking continues the patient will state that he no longer hears the sound of the watch. This may be a perfectly true statement, and is explained by the fatigue of the diseased ear. As will be shown later, some ears affected by chronic aural catarrh manifest this tendency to grow fatigued and to cease to hear a sound, while listening attentively to it.

As a test for bone conduction the watch is limited both by the age of a patient and by the weakness of its impact. The

latter may be covercome by having the ticking apparatus so constructed as to give its sounds with great intensity.

Tuning-forks.—The tuning-fork, like the watch, may be used in two ways as a test.

1. By the air, aerial conduction: this is a test applied to the sound-conducting apparatus chiefly, and only secondarily to the auditory nerve.

The use of the tuning-fork as a test is, however, more frequent in another way, viz.:—

2. By the bones of the head, bone conduction, a test applied primarily to the auditory nerve, and secondarily to the sound conducting apparatus. For, the fork thus used shows whether

Fig. 59.
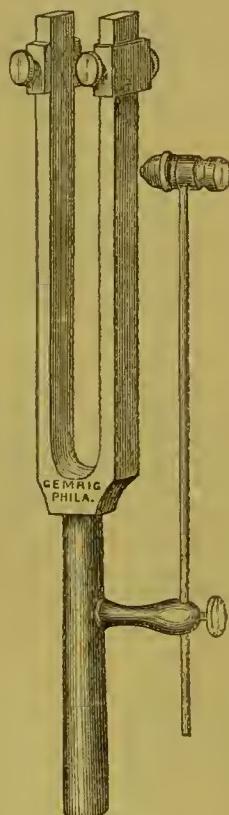
Fig. 60.

BLAKE'S TUNING-FORK.
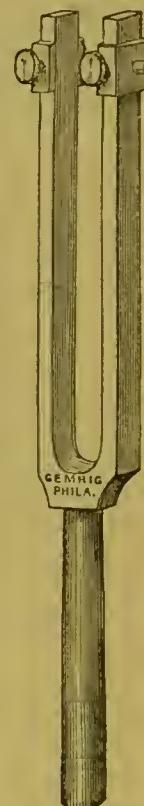
CLINICAL TUNING-FORK.

the sound can be conducted away from the ear in a given case, or whether, being impeded in their escape from the sound conducting parts, the sound-waves are thrown back on the perceptive part of the organ of hearing.

There are several forms of tuning-fork used in making tests of the hearing. The best results are obtained with a large instrument giving a powerful fundamental note. A very beautiful instrument is the tuning-fork devised by Dr. C. J. Blake, in which the force setting the fork in vibration is obtained by means of a steel hammer padded with rubber. The handle of the hammer is adjustable at any point in its length, by which means the blow can be weakened or strengthened as desired.

The clamp with which all tuning-forks should be provided when used in testing bone conduction, are for damping the overtones of the instrument.

An instrument which has given satisfaction and which can be supplied at moderate cost, is the clinical tuning-fork. The instrument is set in vibration by gently tapping it against any firm object, at one of the short stems on the clamp. (See Fig. 60.)

While the force thus applied is not always the same, practice will enable the surgeon to apply nearly the same amount of force in a given case. The instrument possesses the advantage of great convenience and simplicity ; it is 26 cm. long, and gives out a full deep note free from discordant over-tones when the clamps are properly adjusted at the points. By altering the clamps the fundamental note is changed.

Prof. Politzer[1] has devised an acoumeter, consisting of a hard rubber tube 4 centimetres in length, in which is a steel cylinder 28 mm. long and 4 mm. in diameter. Above the latter is a small hammer, which is made to strike the steel rod by touching a spring. There is attached to one side of this instrument a small pedestal, which supports the acoumeter against the head, when it is desired to test the perceptive power of the auditory nerve through the bones of the cranium. All these instruments are said to be made alike, and are attuned to the note c''. Prof. Politzer claims for this instrument the advantage of supplying a standard unit of measurement of hearing.

It may be stated as an axiom, that the normal ear hears the tuning-fork better through the air than through the bones of the head.

[1] K. K. Gesellschaft der Aerzte, Wien, March 2, 1877.

According to Politzer,[1] E. H. Weber first settled the point
that a vibrating tuning-fork, the shaft of which was in contact
with the bones of the head, was heard better in that ear, the
external auditory canal of which was stopped by the finger.
This phenomenon was long unexplained, until Mach, on purely
theoretical grounds, advanced the view that the reason of this
lay in the hindrance offered by the finger in the auditory canal,
to the escape of the sound-waves from the ear. Politzer, having
in mind this phenomenon, thereupon made a series of experi-
ments upon the human ear, and came to these conclusions:—

The above-named augmented perception of sound upon closing
the external auditory canal, is due to (a) the *reflection* of sound-
waves from the bones of the head, through the air of the external
auditory canal, to the membrana tympani and auditory ossicles,
and (b) to the *hindrance* which the sound-waves, passing from
the bones of the head to the labyrinth and tympanic cavity,
meet in escaping from the ear.

In the latter conclusion, Mach and Politzer are in entire
agreement.

If a tuning-fork, vibrating on the vertex, be heard better on
the deafer side, because of the hindrance offered to the escape
of sound-waves, even while the auditory canal is not stopped
by the finger, closure of the meatus by the latter should increase
the sound of the fork's vibrations in the diseased ear.

Dr. Roosa is of the opinion, that, if closing the auditory canal
by the finger does not increase the hearing on the deaf side, it
is a sign that the nerve is affected.

The late Mr. Hinton, of London, was inclined very strongly
to the view, that when, for other reasons, he could diagnose a
nerve affection on the deaf side, an increase of hearing for the
tuning-fork, by stopping the deaf ear, was confirmatory of the
presence of disease of the auditory nerve.

Prof. Politzer has shown that a nerve affection may exist on
the deaf side to such a degree, that the delicate noise of a ticking
watch is not heard better on the deaf side by bone-conduction
so long as the auditory canal is left open; but that, by increasing
the *quantity* of sound made to impinge on the nerve through
the bones of the head, either by stopping up the auditory canal

[1] Wiener Med. Wochenschr., 1868.

and thus reflecting sound from a given source, as when using a watch, or by increasing the original amount of sound employed in the test, as when a large tuning-fork is used, then the diseased nerve, which was too weak to reply to a small amount of sound, is stimulated into action by the greater amount of sound-waves thrown on it.

By remembering this latter fact, the views of Roosa and Hinton are less contradictory than would appear at first sight, for the correctness of each theory is dependent on the amount of nerve-disease. It will then be found that the former is correct if the nerve is paralyzed, and that the latter is right if the nerve still retains some of its function.

Tuning-fork not Infallible in Bone Conduction.—Although the tuning-fork is an important means of diagnosis of disease of the internal ear, it cannot always be relied upon.

Johannes Müller showed that in testing by bone conduction, conveyance of sound through the auditory ossicles and the air must not be lost sight of.[1]

As a rule, the ear which hears better the tuning-fork vibrating on the vertex, may be considered the worse ear. But if one auditory nerve is paralyzed, of course the tuning-fork on the vertex, if heard at all, must be heard in the better ear. If there remains in both ears some hearing for sounds, conveyed by the air, then that one which chiefly perceives the tuning-fork vibrating on the vertex may be considered the less able to perceive by aerial conduction.

Age does not seem to have as much to do with the interference in bone conduction as has been stated by some observers— provided that the fork used is powerful. If the auditory nerve perceives at all, individuals over eighty years of age usually hear the fork vibrating on the vertex. But doubtless it requires powerful vibrations to make themselves felt through the head-bones of the aged. Where bone conduction in the aged seems to be impaired, it is due probably, as Moos has suggested, to a diminishing sensibility of the auditory nerve.

Then too the musical education or sense of the patient, as well as the perceptive powers, must be taken into consideration. If not, hearing will often be confounded with feeling.

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[1] Moos: Klinik der Ohrenheilkunde, p. 41.

It has been found that deaf mutes might, to some, appear to hear the tuning-fork vibrating on the vertex, were it not known that what they perceive in such conditions, are vibrations at the diaphragm.

In the case of a brakeman, struck over the head as the train of cars on which he was standing passed under a bridge, the ears, though entirely and suddenly made deaf to all external sounds by aerial conduction, appeared to hear the tuning-fork vibrating on the vertex. But in this instance it seems rational to conclude that the fork's vibrations were *felt* rather than heard.

Three-limbed Auscultation Tube.—In addition to the patient's statements, there has been advised the use of a three-limbed auscultation tube,[1] two arms of which should be placed in the auditory canals of the patient, and the third in the ear of the observer. If now, a vibrating tuning-fork be placed on the vertex of the patient, the auscultator can perceive the sound of the fork streaming from the ears of the patient. By alternately pressing the two arms of the tube, connected with the patient's ears, the auscultator can further learn from which ear the greater amount of sound comes. Of course it is evident that more sound-waves must come from the less obstructed ear. The latter will, as a rule, be the better hearing ear, unless its fellow is deaf, not by obstruction in the sound conducting parts, but by paralysis of the nerve.

The Interference-Otoscope.—A somewhat similar instrument, though one used in a different way, has been devised by Prof. Lucæ,[2] of Berlin, and named by him the interference otoscope. This instrument consists partly of a double stethoscope of Scott Allison, the limbs of which, intended to fit snugly into the auditory canals of the patient, are about eleven inches long. At the junction of these symmetrical arms is placed a T-shaped glass tube from the portion of which representing the standard of the letter, passes a rubber tube to a collector of sound, half paraboloid in shape. Here the vibrating tuning-fork is stationed.

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[1] Moos : Klinik der Ohrenheilk., p. 42, 1866.
[2] Archiv für Ohrenheilk., Bd. iii. 1867.

To the other end of the cross-piece of the glass tube, is fixed the rubber tube 2 ft. long, for the auscultator.

Dr. Lucæ's experiments in this direction were based on the fact that sound waves, falling on a stretched membrane, are only partly taken up and transmitted by it. The supposition then naturally follows that sound-waves entering the external auditory canal, are only partly transformed into the peculiar pendulum-like, to-and-fro movements of the sound conducting membrana tympani and auditory ossicles. According to the greater or less extent to which the membrana tympani takes up the sound waves falling on it, this so-called reflection of the waves of sound will vary in amount. The investigations made tend to elucidate experimentally this reflection of sound, and the probable influence on it of the changes of tension in the sound-conducting apparatus; also, from a study of these phenomena of reflection of sound-waves, an endeavor is made to obtain an objective expression of the sound-waves taken up by the ear.

The physical experiments show that: 1. A stretched and inclined membrane of India-rubber, placed in an artificial ear made to represent as closely as possible the natural organ, will reflect a certain quantity of the sound-waves entering the external auditory canal. 2. Closure of the Eustachian tube increases slightly this reflection. 3. Increased tension of the membrane shows that the reflection is directly proportional to the tension. 4. This outward reflection of sound-waves is greatest whenever the tension occurs simultaneously with considerable changes in density in the air contained in the tympanic cavity.

In order to make practical application of these laws, Dr. Lucæ devised his interference-otoscope, by which the relative amounts of reflection from both ears could be determined in a given case.

The results obtained by the use of the interference-otoscope (in connection with normal ears), are thus summed up by Prof. Lucæ:—

1. The normal organ of hearing reflects a certain amount of the sound-waves entering the external auditory canal.

2. The reflection increases in all changes of the sound-conducting apparatus, especially in the middle ear, which directly or indirectly lead to an increased tension of the membrana tympani.

3. The examination of those with normal hearing, by means of the interference-otoscope, shows that the different sensibility of both ears for the same tone is caused by the different amounts of reflection brought about by different tensions in the two sound-conducting apparatus.

Respecting the diseased ear, the conclusions are:—

1. The interference otoscope shows in the majority of cases of disease, in analogy with the observations made on those with normal hearing, a *greater* reflection of sound from the worse ear.

2. This is found in a number of cases in which the ear-mirror and the Eustachian catheter reveal disease in the external or middle ear.

3. In the numerous cases of ambilateral chronic catarrh of the middle ear, without perforation of the membrana tympani, the examination usually reveals a *greater*, though sometimes a *less*, reflection from the worse ear; in the latter instance, a simultaneous disease of the labyrinth may be supposed and the prognosis becomes much less favorable.

4. The greatest worth of this method of auscultatory examination lies in the not uncommon cases, in which all other diagnostic means fail to show morbid changes in the external and middle ear; here, too, as a rule, a stronger reflection is observed on the worse side, which points to a deep-seated disease of the sound-conducting apparatus. Only in some few cases does the examination reveal a less reflection from the worse ear, in which cases a primary disease in the labyrinth may be assumed with great certainty.

Tuning-fork Vibrating on a Parietal Protuberance in a Normal Case.—If a vibrating tuning-fork be placed on either parietal protuberance of a person with normal ears, it will be heard in the opposite ear. This is most easily perceived when a large and powerful tuning-fork of deep note is used. This phenomenon, if it may be so termed, will often lead to confusion in diagnosis, inasmuch as the examiner would expect the fork to be heard best in the ear nearest to which the fork is placed. As it is heard best in the more distant organ, a conclusion might be made that the latter is diseased in its conducting parts.

Care must therefore be taken to have the vibrating instrument in the central line of the head, either on the vertex or glabella, or held in or on the teeth. An explanation of the above is, perhaps, most satisfactorily given in Dr. Lucæ's[1] demonstration, that vibrations which fall perpendicularly on the membrana tympani produce the strongest vibrations, and hence a tuning-fork placed on the parietal protuberance, or on the side of the head, will be heard chiefly in the opposite ear. This is very distinctly perceived if both meatus are stopped, but it is equally perceptible, as any one can find out by trying upon himself, with the meatus open.

The tuning-fork finds its greatest usefulness in testing bone-conduction. While it has never fully realized in this way all that was hoped for it as an aid in diagnosis, it is still the best means, and a very good one, too, of determining how much sound is perceived by the auditory nerve, through the bones of the head.

Its musical nature, as well as its powerful vibrations, render it far superior to the watch as a test for the conducting power of the bones of the head, unless the ticking of the watch be made to occur with great force. But should the ticking of the watch equal in intensity the vibrations of the tuning-fork, the former could never approach the latter in musicalness.

The tuning-fork is a means of comparison between bone conduction and aerial conduction of sound, in the same person. For, if the vibrating tuning-fork be held on the vertex until its note is no longer perceived by the examined, and then held before his ear, if he now perceive that the tuning-fork is still vibrating, it is fair to conclude that the sound-conducting apparatus is normal. But, if the fork, when no longer heard through the air alongside of the ear, be heard without being re-struck as soon as it touches the vertex, the conclusion is inevitable that there is some impediment in the sound-conducting part of the ear. This is all the more convincing if it be borne in mind that there is being used the same note, and one, too, growing a little weaker all the time. For, if vibrations of a tuning-fork cease to be heard in front of an ear, by aerial conduction, but are able to communicate themselves while

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[1] Berliner Klin. Wochenschr., No. 10, 1871.

growing constantly weaker, through the bones of the head, the inference of great derangement in the middle or external ear— the aerial sound-conducting parts—cannot be avoided.

Speech.—By hearing speech the intellectual development of the human being is accomplished. There is no sound so familiar and none for which all so fondly long at times, as that of our native tongue. One with good hearing can never realize the feelings of a deaf person so vividly as when traveling in a strange land, surrounded by people speaking with each other happily, gayly, and with varying expressions, but in a language unknown to the lonely traveler. Such a one falls into the position of an invalid, is treated with a kind of pity, and alas, finds himself growing a little suspicious and morose. The deaf person feels the loss of hearing the voice of others more than the loss of power to hear anything else. To recover the ability to hear the familiar tones of his friends' voices he would gladly give up all other hearing. So great is this struggle to hear what others say, that the deaf gradually learn to understand the words of others by watching their lips. The power to hear other sounds well, may begin to fail without the knowledge of the patient, but all his endeavors are concentrated almost unconsciously to catch the varying sounds of speech.

I have known young physicians to be almost deaf to the ticking of a watch without knowing their loss, for their ability to hear speech was good. All aurists are aware that patients are constantly surprised to learn the amount of their deafness as soon as the face is averted from the speaker.

The failure in hearing in this respect is often first detected by the patient in the summer time, when all are accustomed to sit on porches or in the parlor, in twilight and the dark. As the daylight fades and the faces of those around are no longer plainly visible, the hitherto apparently hearing person becomes aware that he is growing deaf. This is often assigned to the night air, but in reality it is due to the loss of vision in the darkness. The surgeon will often gain great aid by a knowledge of these facts, and also by observing how a partially deaf patient will look at the person addressed.

Those of delicate sensibility soonest become aware of their defective ability to hear the voice, for speech is not only a deli-

cate sound, but it is highly valued by the cultured as a means of social intercourse. Those of less sensibility are not aware of their loss of hearing for speech, for they still hear loud sounds, and even music so called, for the latter is comparatively much more powerful than the tones of speech.

The value of speech as a qualitative test for hearing has been shown by Donders, Helmholtz, and O. Wolf. But why it was that a patient could hear some words much better than others, though spoken at the same distance, was not explained and applied until Dr. Wolf, of Frankfurt-on-the-Main, published his investigations respecting the acoustic characters of the various elements of speech.[1]

The human ear perceives, as music, tones varying from 16 vibrations to 20,000 vibrations in a second. Preyer[2] has lately placed these limits from 15 vibrations to 40,960 vibrations in a second. Blake[3] has shown that the human ear, in some instances, distinctly hears, as musical tones, 35,000 to 40,960 vibrations in a second.

Speech, according to Wolf, embraces only eight octaves, viz.: R. of 16 vibrations, and S. of 4324 vibrations in a second. It may be said, therefore, to lie entirely within the limits of music.

Perception of High Musical Tones.—With the view of ascertaining the power of the ear to perceive high musical tones, Dr. Blake[4] has performed a series of most valuable experiments with König's rods. The latter are steel rods devised by Mr. König, of Paris, for making accurate acoustic tests with notes of highest pitch.

In order to get a clear tone, it is necessary to suspend the rods by means of loops of silk, or fine wire. To obtain the points at which the threads should be attached to the steel rods, the length of the rod should be divided by 4.3. Thus if the length is 70.5, this divided by $4.3 = 16.4$. The latter would be the distance from each end, at which the loop of the suspending thread should pass round the rod. Then Dr. Blake suggests

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[1] Sprache und Ohr., 1871.   [2] Jena, 1876.
[3] Transactions American Otological Soc., 1872–1873.
[4] Summary of results of experiments on the perception of high musical tones. Tr. Amer. Otol. Soc., 1872.

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that in order to obtain a determined intensity of tone, a small steel pendulum, swinging through an arc of 90°, be suspended to the same beam as the steel rod. If the pendulum is made to swing over the arc on which a graduated scale may be placed, the intensity of the blow can always be known and reproduced exactly, if necessary. With this instrument, Dr. Blake has found that the perceptive power of hearing high musical tones varies with the age. At about the age of 12 or 13 years, a tone of 40,960 *vibrations per second* was heard 34 feet; at the ages of 18 to 20 years, the same tone was heard at distances of only 13 to 16 ft., while at 34 ft. only the tone of 36,864 vs. was heard. At the ages of from 28 to 30 years, only tones of 32,768 vs. were perceptible, while above the age of 50 years the limit of perception, at the same distance, had still further diminished, and in a greater variety of degree. Dr. Blake's further investigations showed that these changes in perceptive power were due to thickening of the membrana tympani, the latter causing diminution of the power to hear the high tones. An apparent exception occurs, where in addition to thickening, especially in the young, the membrana tympani is drawn in. The increased tension of the latter condition makes the membrana tympani more sensitive to high tones, and thus the thickening of the membrane is somewhat counterbalanced. In two cases of voluntary contraction of the tensor tympani, the perception increased from 3000 vs. to 5000 vs., during the contraction of the muscle, above the limit of perception observed when the muscle was not contracted.

Fig. 61.

König Rod as modified by Blake.

Further experiments of Dr. Blake showed that when the membrana tympani is perforated, especially at the posterior and superior periphery, the ear can perceive higher notes than when the membrane is intact. This was found to be the case both when perforations had been made by disease, and after artificial perforations.

In one instance, after Politzer's cyclet had been inserted into a thickened drum-head, a steel rod, with a tone of 80,000 vs., was distinctly heard 3 in. from the ear.

In a later paper Dr. Blake[1] bases the claims of high musical tones, to value in diagnosis, upon the following facts: "That the limit of perceptive power of the cochlea exceeds the limits of sound-transmitting power of the structures of the middle ear in their normal condition; that the structures of the middle ear in their normal condition, therefore, present a barrier as it were to the passage of sonorous vibrations above a given point; and that the perceptive power of the internal ear remaining the same, morbid changes in the middle ear result in a variation in the limit of their transmission of musical tones." This variation may be either above or below a certain standard point; this point as already stated was found to be about 40,000 vs.

When the membrana tympani is perforated the ear may perceive musical tones of 100,000 vs.; the difference between this tone and the tone given as the normal standard may be regarded "as the measure of the degree of resistance, so to speak, which the structures of the normal middle ear present to the passage of the short sound-waves of the higher musical tones."

Acoustic Character of Vowels and Consonants.—The distance at which separate *vowels* can be heard has not yet been established, but they are endowed with the greatest strength of tone, being heard and understood at a distance at which all the consonants are inaudible. The intensities of vowels given here are such as are obtainable when words containing the given vowels are uttered. The consonants differ very greatly from each other in strength of tone, as will be shown further on.

Vowel-sounds are composed of a number of beautifully harmonic over-tones, which accompany the fundamental note and strengthen that of the mouth. A good musician can hear a perfect accord when a vowel sound, specially A, is uttered with clearness, which is said by Wolf and Appunn to be most observable when the sound is made in the open air, where the sound waves escape with greater precision than in a room. Dr.

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[1] Diagnostic value of high musical tones. Transactions American Otol. Soc., vol. i. p. 438, 1873.

Wolf has shown that the broad sound of A has the most over-tones, five in all, and is heard the furthest, 360 paces. The sound of Oo has the fewest over-tones, three in all, and is heard with the most difficulty of all the vowels. It can be heard distinctly 280 paces. The vowel O, containing many beautiful harmonic over-tones, is heard nearly as far as the broad A.

The German E, about equivalent to the English A, is heard 330 paces, and the English E is heard 300 paces. English I is somewhat more powerful (340 paces) than A, but weaker than the broad A or the O sound. Oi is nearly equal to E. Weakest of all diphthongs is Ou, as in out; it is a little stronger than Oo.

Consonants.—Consonants may be classified according to their acoustic and physiological laws, under two heads, viz., those which are self-sounding, and those which are sound-borrowing.[1] The former are such as possess a sound entirely independent of association with a vowel sound, and one that can be defined respecting its pitch, intensity, and timbre. The latter are such as must be either preceded or followed by a vowel in order to render them audible, and hence the name of sound-borrowing consonants has been applied to them by Dr. Wolf, of Frankfurt-on-the-Main.

H is the weakest of all consonants when pronounced without a vowel. It is lost at the distance of a few paces. Next in strength is B, *Ba* being heard further than *Ha*. B alone is heard at a distance of 18 paces. The deeper a note is the less effect it has upon the ear. The high notes are the most valuable in this respect, as shown by Moos. R, with only 16 vibrations in a second, is not distinguishable further than 41 paces. K and T stand next; they are both heard equally well at 63 paces. T resembles pretty closely a simple note, but it has a pitch which appeals more readily to the ear, and is, therefore, heard much better than B, which is otherwise very similar to it. K is formed with relatively favorable circumstances, by means of a powerful movement of the root of the tongue. The soft F is heard somewhat further than the foregoing letters, *i. e.* 67 paces. S is perceived at a relatively greater distance than

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[1] "Selbsttönende" and "Tonborgende," Wolf; Sprache und Ohr, pp. 14–15.

the foregoing, on account of the pitch of its fundamental note, which by its sharp character attracts the ear.

" To its properties as a sibilant consonant it owes its ability to express disapprobation in public assemblies, to cry down opposing sentiments, and to enforce silence. Both its moral and physical character are inharmonic." S can be heard very distinctly 170 paces. Sch German, nearly equal to Sh English, is heard furthest of all consonants, because it possesses full and rich clang-tint, and is composed of three harmonic notes which predominate while the inharmonic over-tones recede; this composite consonant can be heard 200 paces. M and N unaccompanied by vowels are only meaningless blowing of air through the nostrils. Mama and Nana are understood 180 paces, but at a greater distance the sounds of M and N are lost while the vowel A is still heard.[1]

Helmholtz has also pointed out the very noticeable fact that if in calm weather an observer be placed on some elevation near a town—a tower or a hill-top—it will be found that words are no longer distinguishable, or at best only those composed of M and N with vowels. Vowels can be heard following each other in a curious interchange and with remarkable cadences, because no consonants are heard and the other vocal sounds cannot be joined into words.[2]

It is thus shown that in the component sounds of speech a wide range of tests of different intensities and pitch is offered to the aurist. Such a numerous set of tests is needed in order to discover which sounds are heard best by an affected ear. One sound is not sufficient, because an ear may be unable to hear certain sounds, but comparatively good for others. Hence if only one or two sounds should be employed, as in the watch, just those sounds might not be heard as well as others. No sound-unit has ever been established, and, if it were, it would be useless, since, from the nature of the ear, such a unit would not be equally applicable in all cases. Therefore speech becomes valuable as a test because of its composite sound-nature, and also because it is ever at the command of the examiner, whose object in applying it as a test is comprehended by the patient without

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[1] Wolf; op. cit , p. 63.
[2] Tonempfindungen, etc., p. 118.

any preliminary instruction.   By using speech as a test an average condition of the ear can best be obtained.

Whispering and Loud Tones.—Very often whispers and words spoken in low tones are heard much more distinctly by the affected ear than loudly spoken words.   This is due to the damping of vowels, as shown by Wolf, whereby the consonants, which have been stated to be less sonorous than vowels, have a chance to be heard.   This fact is of great importance, not only in estimating the hearing, but in addressing those hard of hearing.   Members of a family very often pitch their voices too high, and hence confuse the afflicted one, thus gaining the idea that the individual is deafer than he really is.   On the other hand, they are surprised that on some occasions he hears sounds and words spoken to others in comparatively low tones.   So marked is this in those hard of hearing, that it has been said a deaf person always hears when it is especially desired that he should not.   This is due to the physiological acoustic fact mentioned above, that in low spoken tones the vowels are quelled, and the consonants, being allowed thereby a better utterance, are relatively strengthened, and the whole word is heard better than if roared out.   This damping of vowels has both its good and bad side.   Do not elevate the voice too high when you wish to make a deaf person hear, but do not lower it too much, unless to a whisper, if it is not desired that he should hear.

Words may be heard even when the letters composing them, spoken separately, are not heard.   This is especially so for the letters B, P, T, K, and R.   The reason of this lies in the fact that letters pronounced alone are really words.   Thus B is really composed of sounds of *b* and *e*, as in *be*; P, of *pea* or *pee*; K, of *kay*, while R is equivalent to sounds of the word *are*. It may be said very truly, that in the latter instance, R, when pronounced alone, is altogether of a phonetic value different from that when standing at the beginning of a word, as in *Rab*, or at the end of a word, as in *Tar*.

Whispering.—Whispering has an advantage over loud words in testing, since the former cannot be as easily conveyed as the latter through the bones of the head to the auditory nerve. However, it must be borne in mind that in a case reported by

Dr. Dennert,[1] in which the cochlea had been lost by necrosis, the *normal* ear, though artificially stopped up as thoroughly as possible, could yet hear whispers six feet off. Sometimes, patients hear music better than speech, because the faintest music of an orchestra is more powerful than speech, as stated by Wolf.

Variable Hearing.—The hearing varies very greatly in cases of movable fluid in the tympanic cavity and in some forms of aural vertigo. When such peculiarities of hearing are fully established, they may aid greatly in diagnosis. The first kind is made manifest by changes of position of the patient's head; the second form of variability of hearing comes and goes with the paroxysm of vertigo. It is probably due to alterations in the condition of the muscles in the tympanum, whereby altered tension in the sound-conducting apparatus is produced.

Hearing Low Tones better than High Ones.—It is sometimes observed by patients that they hear low, bass notes much better than high ones; as for example, in two instances, patients volunteered the information that they heard thunder much better than the chirping of crickets, and bass notes much better than high ones on the piano or organ. In testing with a watch, it was found that one giving out the deeper note was most easily heard by one of these patients; the other was not thus tested. Experimentally, I have shown that a deep note has the advantage of high notes in cases of increased labyrinthine pressure. In an increase of such pressure, the stapes becomes more fixed, and it is on this small bone that the vibrations begin to grow less as the pressure within the labyrinth is increased. In such a case, it is manifest that, if vibrations from without are normally conveyed to the stapes, there they must meet with hindrance in their endeavor to reach the labyrinth. Only the more powerful sound-waves are able to overcome this obstacle and force the stapes into to-and-fro motions with the rest of the chain of ossicles. I have, therefore, thought it might be asked, could not the inability to hear high notes in some cases, while low ones are heard nearly, if not quite, normally, be construed

[1] Archiv f. Ohrenh., vol. x.

into a sign that the stapes is impeded, either by undue pressure in the labyrinth, or by catarrhal fixation in the oval window? That the cause of such a peculiar alteration in hearing probably does not lie in an undue tension in the membrana tympani, appears from the well-known physical fact that the tense membrane is more susceptible to vibrations of high notes than to those of the low.

The Position and Extent of Perforation in the Membrana Tympani may cause variation in the hearing power for certain sounds, especially consonants, as shown by Wolf.[1] Experiments with the consonant B upon defective drum-heads show that the perceptive power for this sound diminishes as the extent of the defect increases. The faintness of the consonant is most observable when it stands at the end of the word. It may also be said that defects of the membrana flaccida are attended with great deafness for all sounds, which is probably due to an implication of the malleo-incudal joint.

Testing the Hearing in One-sided Deafness.—In measuring the hearing for sounds conveyed through the air in cases of one-sided deafness, or of hardness of hearing confined chiefly, if not entirely, to one ear, care must be taken not to attribute to the worse ear that which is really heard by the better ear, though stopped and turned from the examiner. In any case where one ear is being tested, accuracy would demand the isolation of the other. Usually, the ear not being tested is stopped and turned from the source of sound, the ear under examination being left open and turned towards the sound-source. This method will usually give at least a proximate result as to the amount of hearing in the worse ear, but in order to exclude the fact that the better ear, though stopped and turned away, hears some of the test, it will be necessary to measure the hearing in the worse ear alternately open and stopped, in order to see what effect this stoppage will have upon the amount of hearing it is supposed the worse ear still retains.

In the method of Dennert and Lucæ,[2] the voice is relied upon chiefly for the test. The *better* ear is stopped, turned towards the source of sound, and tested, the deafer ear being alternately

[1] Sprache und Ohr., 2d part.   [2] Archiv f. Ohrenheilkunde, 1875.

opened and closed. The difference in the hearing, if there be any elicited by this method, is set down to the worse ear.

To diagnose deafness of one side, Dr. H. Knapp[1] proposes the passing of a vibrating tuning-fork backward and forward, past the affected ear stopped up. If no difference in the sound of the fork is perceived as it nears the meatus, then it may be concluded that sound has reached the brain by the other ear.

A plan similar to the foregoing, and one which I have used for a long time in cases of one-sided deafness, is as follows: Place the patient so that the affected ear is towards the surgeon. Then with the finger stop the ear not to be tested. This may be done by the patient or by an assistant, preferably by the latter when great certainty is needed. Now, with the affected ear open and turned towards the surgeon, let tests of its hearing power be made. When the limit of hearing on that side is obtained, let the ear be closed as the other ear is, and then, with the affected ear still turned towards the examiner, let tests be made again. If the closure of the deaf ear causes no difference in the hearing distance already obtained, it is fair to conclude that whatever amount of hearing exists is not due to passage of sound through the external auditory canal of the worse ear turned towards the test. In such a case the conclusion must therefore be, that sound either goes more easily through the bones of the head on the affected side than through the meatus, to the auditory nerve (which would be absurd), or that sound has reached the brain by the other ear. Also, it may be concluded that the thus affected ear is totally deaf.

If, however, stopping the ear turned towards the examiner (the ear supposed to be the deafer) makes that ear still deafer, let the examiner approach the patient and repeat the tests until they are heard once more. The second hearing of them is evidently due to conduction of sound through the cranial bones and the finger in the meatus, and therefore must not be mistakenly regarded as aerial conduction. The extent of the power of the ear to hear in this latter way will be expressed in the difference between the limit of hearing the first test and the limit of the second. Thus, a patient may hear speech as far as eight feet, with the good ear stopped and turned away, and the

[1] Archives of Oph. and Otol., 1875.

affected ear open. When the latter is stopped, but still turned towards the examiner, speech is no longer heard at eight feet, but it may be perceived by the patient at a distance of three feet, both ears still being kept firmly stopped. In such a case, not the former distance, but the difference between it and the latter distance, viz., *five* feet, must be regarded as the limit of aerial conduction by the external auditory canal, for that represents the *amount of loss of hearing caused by stopping the meatus.*

Whatever is heard just as well with the deafer ear stopped as when open, the better ear remaining stopped throughout the testing, must still be heard by the better ear through the head ; but whatever is heard only with the worse ear open, the good ear being stopped, must be attributed to the worse ear.

Another method of getting at the amount of hearing in a very deaf ear, or perhaps a totally deaf one for all that is known before the examination, is to begin the testing with both ears of the patient closed. Then, with the worse ear toward the sound-source, try to find out how much is heard ; after which let the artificial stoppage, usually accomplished either by the finger of the patient or of an assistant, be removed from the worse ear, the better one remaining stopped.

The difference in the two results, if there is any, must be the true amount of hearing on the affected side. If there is no difference in the result, it is fair to conclude that sound conducted through the auditory canal to the deaf ear is not perceived by it. This being the case, if words repeated on the affected side are still heard, it is not due to any remnant of hearing power in the deaf ear, but rather to the passage of sound through the head to the good ear.

The question might be asked, why cannot sound be conveyed to the deaf ear through the head, if it is conveyed to the better ear, which is stopped and turned away from the sound-source? The reply would be, that an ear which, either when stopped or open, perceives no difference in sound conveyed by the meatus, is not sensitive enough to hear sound conveyed to it through the head.

The Entotic Application of the Ear-Trumpet.—In order to find out which parts of the chain of ossicles are most affected in cases of sclerosis and stiffening of these portions of the middle

ear, it has been proposed by Dr. Albert Bing,[1] of Vienna, to substitute the ordinary means of diagnosis found in the catheter, the auscultation tube, and in the direct inspection of the membrana tympani, by what he terms the entotic application of the hearing trumpet.

This is done by speaking through a collector of sound, one end of which is made to communicate directly with the tympanic cavity, through a catheter fixed in the Eustachian tube. By such an apparatus, sound-waves may be brought directly into the tympanum and made to fall immediately upon the foot-plate of the stapes, from which they are carried over to the fluid of the labyrinth and the auditory nerve. During the examination by this mèthod, the ears of the patient are to be stopped, in order to prevent sound from entering by the external auditory canals, and, in order to prevent lip-reading, the eyes of the patient should be closed; he may then be required to repeat what he hears.

According to the greater or less ability of the patient to hear by this method, Dr. Bing concludes that, 1, the stapes is entirely normal, or 2, that it is more easily movable than either of the other ossicles; 3, that the obstacle to conduction lies only in the stapes or in it and the other ossicles at the same time, or 4, that the stapes has become anchylosed. In one instance in which the patient heard much better by the entotic method, until a perforation in the drum-head was freed of tough exudation, when he heard better both with and without the trumpet, it was concluded that the chief obstacle to conduction of sound lay in the malleus and incus, while the stapes was easily moved.

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[1] Die entotische Anwendung des Hörrohrs.   Monatsschr. f. Ohrenheilkunde, Nos. 8, 9, and 10, 1876.

SECTION II.

AURICLE.

CHAPTER I.

ORGANIC DEFECTS AND CUTANEOUS DISEASES.

ORGANIC DEFECTS.

AMONG organic defects in the auricle may be mentioned, absence, plurality, abnormal position and shape, as well as partial and defective development.

A partial or total want of the auricle may be congenital. This may be confined to one side, or it may occur on both sides and in conjunction with other defects of the head produced by alteration or imperfect development of the visceral arches. Such defects interfere more or less with the fineness of hearing.

Traumatic loss of the auricle frequently occurs from accident, punishment, and disease.

The *treatment* consists in procuring the best kind of artificial external ear; for plastic operations so far have not done much, if anything, towards giving a sightly ear in place of the lost one.

Plurality and Abnormal Position of Auricles.—A plurality of auricles has been found in lower animals[1] and in man. "Casse-bohm relates a case of a child with four ears, two naturally placed, and two lower down on the neck; there were in this instance two petrous portions in each temporal bone."[2]

Birkett[3] has reported the case of a young girl who, in addition to irregularities in her ears, had on each side above the middle

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[1] Especially in the Pig, Wilde, op. cit., 161.
[2] Wilde, op. cit., p. 161.
[3] Transactions of Path. Soc. London, 1858, vol. ix. p. 448.

of the sterno-cleido-mastoid muscle, a large growth resembling the lobule of an auricle, each supplied with an artery, and containing reticular cartilage like that of the pinna.

Malformations of the Auricle.—Malformations of the auricle are generally found connected with defects or absence of the external auditory canal. The surgeon is usually consulted to know whether the malformation will interfere with the hearing of infants thus deformed, and if so whether an operation will relieve the deafness and deformity.

Mr. S. Cooper[1] states that he had seen a child without ears, exhibited as a curiosity in London, in whom there were no external auditory canals, but the child " could hear a great deal although the sense was certainly dull and imperfect." There are many other cases on record of malformed auricles and external ears, and in some cases there is a very defective development of the middle ear ; yet the auricle many be deformed, while all the rest of the organ of hearing is normal.

Mr. Toynbee[2] in his excellent work has given an account of a paper by Prof. Allen Thomson,[3] treating of malformation of the external ear and the condition of the hearing in such cases. It is there shown that in an incomplete development of the integumental part of the apparatus, viz., the auricle and outer part of the meatus, there is usually absence of the tympanic ring and consequently of the bony part of the meatus, that there is also a defective state of the cavity of the tympanum and chain of small bones, and occasional irregularity or deficiency in the development of the malar, palatal, and maxillary portions of the face and mouth.

Gruber[4] has stated that in deformities of such a high grade he has never found a normal auditory canal. Usually there is not a trace of one present, or at best it is a narrow and short blind passage connected with the auricle. The latter usually does not occupy a position similar to that of a normal auricle, but is either nearer the check or pushed downward towards the

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[1] Cooper's Surgical Dict., 7th ed., p. 470.
[2] Diseases of the Ear, London, 1868, p. 14–15.
[3] Edinburgh Journal of Medical Science, April, 1847.
[4] Lehrbuch der Ohrenheilk., p. 275.

throat, and is movable in all directions with the neighboring skin.

This is an important fact to bear in mind, if there is any inclination to make an artificial auditory canal.

Of the two cases reported by Dr. C. J. Blake,[1] the following is considered by him as of great interest:—

It occurred in the right ear of a girl three years old; the long diameter of the auricle formed an angle of 45° with the vertical plane of the head; the position of the helix was barely indicated by a slight reduplication of the superior portion of the auricle, and the antihelix represented by a slight elevation above the superior border of the concha; the whole of this portion of the auricle resembled that of the chimpanzee, or of the cases of dementia given by Prof. Laycock.

The meatus was represented by a slight depression bounded anteriorly by a well-formed tragus, which latter was supplemented anteriorly by a small cartilaginous nodule, as in the cases described by Gruber.

The most interesting and important part of this history is that relating to the auditory meatus and the hearing on the affected side. Dr. Blake says: "The perception for musical tones on this side of the head seemed to be good, and the integument covering the meatus could easily be depressed with a probe.

"Under these circumstances an exploratory operation was advised, but, unfortunately, the patient did not return at the appointed time. The family history of the patient gave no other case of malformation, and the little patient herself was otherwise normally developed."

A case of congenital one-sided bony closure of the external auditory canal with rudimentary development of the auricle, was observed by Dr. H. Knapp[2] in a healthy child three months old. The auricle consisted of a slightly tortuous ridge, was two lines high and three-quarters of an inch long. "It felt rough to the touch like a healthy auricle, being undoubtedly composed of cartilage and skin. Its shape represented the rudiments of the helix and lobule; the other parts of the auricle

¹ Statistical Report, 1652 cases of Diseases of the Ear. Mass. Charitable Eye and Ear Infirmary, 1872.
² Transactions American Otol. Society, vol. i. p. 116.

were not visible. Immediately before the middle of the rudimentary auricle, there was a small round depression, indicating the situation of the external meatus."

Upon making an incision through this depression the knife struck a bony obstruction indicating occlusion of the auditory canal by hard bone, and demonstrated the uselessness of further operative interference.

The child was too young to give any information as to the condition of its labyrinth when tested with the tuning-fork.

Congenital Fistula of the Ear.—This is a rare form of malformation or arrested development in the ear. Cases of it have been described by Schwartze, Heusinger, Schede, Schmitz,[1] and Pflüger.[2]

It consists in a small fistulous opening close in front of the tragus, which may extend in some cases as far as the tympanic cavity. It may be symmetrical, as shown by Pflüger, or in connection with defects in the throat, as shown by Schmitz. In the case given by Dr. Pflüger a probe could be inserted $1\frac{1}{2}$ cm. without difficulty or pain. An interesting fact connected with the history of this case was that pus had been discharged a number of times from these openings, after attacks of earache. The cause of this anomaly is considered by Heusinger, Schmitz, and Pflüger to be an arrest of development in the first visceral cleft, a view also held by Virchow.

CUTANEOUS DISEASES OF THE AURICLE.

There are some cutaneous diseases of the auricle and of the parts adjacent to the ear which may fall to the care of an aural surgeon; such as erythema, erysipelas, intertrigo, frostbite, and chronic inflammation of the skin of the auricle.

Simple Erythema.—This disease is usually caused by local irritation from bites of insects, badly fitting head coverings, especially in infants, the action of the sun on the exposed ear,

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[1] Ueber fistula auris congenita, etc., Halle, 1873. A. f. O. B. ii. N. F. 1874, p. 301. Abstract by Jacoby.

[2] Monatsschr f. Ohrenheilkunde, No. 11, 1874.

and the instillation of various nostra into the ear, or by irritating discharges from the organ itself. The membrana tympani may not be affected.

Treatment.—In mild cases of erythema of the auricle very little treatment is demanded. If the itching and burning are great, it is best to use sheathing dressings, such as cream, ung. aquæ rosæ, simple cerate and the various mucilages, an excellent one being quince-seed mucilage.

Erysipelas.—Erysipelas of the auricle may occur as a primary or idiopathic disease from local cold, or secondarily by extension of the disease to the auricle from parts adjacent to it. In the latter instance the prognosis will depend greatly upon the condition of patient and the previous condition of the ear.

While erysipelas of the face and head as a rule will render hearing in any case dull, most probably by an occlusion of the auditory canal, it does not necessarily leave the hearing permanently impaired. Even where erysipelas attacks an ear previously diseased, the bad consequences are not permanent. In the case of a young lady, 18 years old, I have seen four or five attacks of erysipelas of the face in the course of a few years. On the right side she has a chronic purulent discharge from the ear, dating from early childhood. During the time she has been under my observation the erysipelas has always made the condition of the diseased ear temporarily worse, but notwithstanding the repeated hindrances to recovery, experienced by the ear, it has gradually assumed a more healthy condition.

Treatment.—The treatment of erysipelas of the auricle is similar to that of the disease elsewhere, excepting that care must be exercised not to apply such cold dressings to the ear as would be justifiable in the disease on the face. It is preferable to apply light dressings to the erysipelatous ear, such as light gauze or linen sprinkled with flour or rice-powder, and to *avoid cold moisture.*

Intertrigo.—This disease may be found in children of all classes, and in the healthy as well as the unhealthy. It is caused by mechanical irritation where the posterior surface of the auricle comes in contact with the mastoid surface. It is

due primarily to a certain amount of maceration of these surfaces, which favors excoriation and chafing. Hence dryness behind the auricle must be maintained. Cleanliness of course must be observed, but too much washing is as bad as too little. The disease may also be caused by too much warmth about the head, tightly fitting caps, picking at the ear on the part of the children themselves, and by tossing or working the head about on the pillow, which of course causes the auricle to rub against the mastoid surface. The prognosis is favorable. The disease should be arrested as soon as possible in order to prevent it from passing into an eczematous condition.

Treatment.—After the disease is fully established all washing of the parts behind the ear should cease, and the moist surfaces be dusted with a powder consisting of one part of oxide of zinc (Hubbuc's preferable) and seven parts of pure starch. This will form a white crust, which should be let alone until it drops off, when the surface underneath will be found to have entirely healed.

Frost-bite.—In very cold winters with us, and in cold climates every winter, frost-bitten ears are not uncommon. No special treatment is demanded in acute cases. Care must be taken to avoid too sudden a reaction, and this is done by the application of ice-water or snow at first, with the gradual application of warmer water. If vesicles and subsequent excoriation occur, we must prevent the access of air as much as possible to the affected parts, by the application of emollient cerates or collodion.[1] In order to prevent a return in the following winter, the same authority advises that, during the summer, the auricle be carefully and thoroughly washed with cold water, to which a little alum should be added. In many cases, when nothing better can be procured, the excoriations, produced by the frost-bites, on the auricle, may be covered by linen smeared with ordinary glue.[2] New formations of cartilage may occur throughout the entire helix and the major portion of the pinna, as a result of frost-bite, and hard and sensitive nodules may be felt in the lobe. In such a case, seen recently by the author, the skin was purplish, covered with a

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[1] Rau, op. cit., p. 161.   [2] Ibid.

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slight amount of branny scales, and the nodules could be distinctly seen as well as felt. The nodules in the auricle in this case did not resemble the gouty deposits described by Garrod.[1] They were so close together that the surface of the cartilage of the auricle had lost entirely its smoothness. At the same time, the entire auricle, especially at the more elevated nodules, was quite sensitive to pressure.

Tophi, as described by authors treating of gout, do not appear to be very common in this country.

Lupus erythematosus, lupus vulgaris, psoriasis, ichthyosis, comedo, acne, keloid, molluscum fibrosum, with the disease elsewhere on the body, and ringworm, may attack the ear; but beyond the mere mention of their occurrence, it is not necessary to enter into a discussion or description of them here. The reader is earnestly requested, however, to bear in mind the possibility of these diseases being found on the auricle and concha, and in the auditory canal, and to become acquainted with their nature and treatment as set forth in works on dermatology.

Pemphigus Gangrenosis of the Auricle.—This disease was first described by Dr. Whitley Stokes, and mentioned by Wilde[2] in the medical memoir attached to the census of Ireland in 1841. It is peculiar to Ireland, very apt to attack children on or about the ears, is very fatal, and prevails especially among the lower orders. It is said to have caused 17,799 deaths in ten years in Ireland, the truth of which, Wilde is inclined to believe. It is not known in this country, though the scars left by it have been seen by the author, in an Irish woman.

Phagedæna, or cancrum auris and gangrene from embolism, may be mentioned as of uncommon occurrence.

Gangrene of the ears occurs in some low fevers; it may be symmetrical and associated with gangrene of the nose. It has been observed after intermittent fever by H. Fischer,[3] and after typhus by Estlander.[4] Gangrene of the auricle is similarly

[1] Treatment of Gout, London, 1859.
[2] Diseases of the Ear, American ed., 1853, p. 174.
[3] Langenbeck's Archiv, vol. xviii. pp. 335-339.
[4] Quoted by Fischer.

referred to by Patry,[1] and by Barker and Cheyne.[2] It is usually
a very bad symptom, being the immediate precursor of death
in most cases, though recovery has ensued after gangrene of the
ears had occurred in typhus fever, as shown by Estlander, and
by Barker and Cheyne. It is generally associated with livid
and gangrenous spots elsewhere on the body.

Eczema.—Eczema, both in the acute and chronic form, may
be found in the auricle, and, as a disease modified by its seat
in an organ of special sense, becomes of interest to the aurist.
The *acute* form is more common than the chronic, attacks all
ages and sexes, but is more frequent in children and in
females. It is supposed to be connected with the phases of
menstruation, and is considered by some, to be, with other
symptoms, indicative of the menopause.[3] In children, acute
eczema is often produced artificially by uncleanliness, by their
own picking at the ear, and by head coverings which fit too
closely. In adults, acute eczema of the ear is frequently
caused by the introduction into the organ, of improper reme-
dies for earache, toothache, etc.

Acute Eczema of the auricle or auricles may be idiopathic or
an accompaniment of other diseases of the ear, or it may occur
in the auricle from the contiguity of the latter to other parts of
the head affected by the disease. The idiopathic form may
appear on *both sides* of the auricle, or it may be circumscribed
on the anterior surface. The greatest interest this disease can
have for the aurist, is when it attacks the auditory canal and
invades the membrana tympani.

Treatment.—The treatment of eczema of the auricle will be
similar to that of eczema anywhere else on the general surface,
with of course the modification rendered necessary by care not
to apply any remedy which, by escaping into the auditory canal,
would injure the drum-head. The treatment of the *acute* form
of eczema of the auricle should always be very simple, and the
dressings, when once applied, should not be changed more than
twice daily.

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[1] Archives Générales, 1863, i. p. 144.
[2] Observations on Fevers, etc., p. 232, vol. i. See also Toner Lecture for
1877, by Wm. W. Keen, M.D.
[3] Gruber, op. cit., p. 288.

Prof. Gruber has found that both glycerine and cod-liver oil, applied on pledgets of charpie, and bound firmly to the eczematous auricle, are of great value in children.[1]

The following powders will be found of the greatest benefit in acute eczema of the auricle :—

R.—Flor. zinci, ʒij ;
Aluminis,
Amyli, āā ʒj.
M.   Fiat pulv.

Another, equally useful, is as follows :—

R.—Zinci ox., ʒj–iv ;
Amyli, ʒvij–iv.
M.   Fiat pulv.

These powders should be dusted carefully and thoroughly over the diseased auricle, and the latter should then remain undisturbed as much as possible, for, the general advice not to wash any part affected with acute eczema, holds good in the treatment of acute eczema of the auricle.   The ointment of the oxide of zinc, benzoated, is also a very efficacious remedy in eczema of the auricle.

If the heat and burning become very great in acute eczema of the auricle, *cold* must be applied, with caution, to the diseased surface.   This is best done with cloths steeped in cold water.

Hebra[2] has lately used in acute eczema, a salve which he calls the Ung. Diachyli, which is made as follows :—

R.—Ol. olivæ, opt. fl℥xv ;
Lithargyri, ℥iij ʒvj ;
Aquæ, q. s.
Coque.   M.   Fiat Ung.[3]

This may be used in acute eczema of the auricle.   The salve may be rubbed in with the finger two or three times daily, or it may be smeared on linen and the latter applied as a plaster.

Subacute Eczema.—Should the eczema pass, as it is apt to do, into a subacute form, characterized by great swelling,

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[1] Lehrbuch d. Ohrenh., 1870, p. 292.

[2] See Gruber's Lehrbuch d. Ohrenheilk., p. 294.

[3] This ointment is difficult to make, requiring more than ordinary pharmaceutical skill.   That form prepared by McKelway & Borell, Cramer & Small, and Mr. J. P. Remington, of Philadelphia, is recommended by Dr. Duhring, *Diseases of the Skin*, p. 188, which see.

vesicles, and fissures in the skin, the auricle should be thoroughly rubbed twice daily, with sapo viridis, the Schmierseife of the Germans. Then the disease should be treated as an acute form.

The subacute form of eczema of the auricle may be treated beneficially by the application of *acetum cantharidis* to the sluggish parts, and then pencilling the latter with the following :—

> R.—Ol. cadini, fl꒞ij ;
> Alcohol, fl꒞j.

This will often prevent the disease from becoming chronic.

Treatment.—In chronic eczema of the auricle, the aim must be to allay irritation, and at the same time to stimulate the parts into a healthy action. Attention must also be paid to the general condition of the patient, and the internal treatment by means of alterative tonics, among which arsenic will be found highly efficacious, will play an important part in the management of the chronic forms of this disease.

Various kinds of *local* treatment have been proposed for the chronic form of eczema of the auricle, among which, the best are painting the diseased parts with acetum cantharidis, nitrate of silver (gr. x–fl꒞j aq.), and the application of emollients, the head being kept dry and cool. It has also been proposed[1] to coat the auricle with a solution of gutta-percha in chloroform, or to apply to it various forms of ointments of zinc and ammoniated mercury (U. S. Pharm.). The ointment made of the latter, I have found most useful, as suggested to me by Dr. L. A. Duhring, of Philadelphia, in the following formula :—

> R.—Hydrargyri ammoniati, gr. x–xx ;
> Adipis, ꒞j.
> M. Fiat unguentum.
> S. To be rubbed gently but thoroughly in.

Dr. Duhring[2] places the preparations of tar among the most useful remedies, after the acute stages have passed away. The use of solutions of potassa, followed by stimulating ointments, are also highly recommended. Dr. Duhring's experience has

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[1] Wilde and Graves. See former, op. cit., p. 173.
[2] Treatise on Diseases of the Skin, p. 207–208, 1877.

been that eczema of the auricles is usually obstinate in its course.

When the eczematous disease has invaded the canal, and stimulation of the parts is needed, an ointment may be used, composed as follows:—

R.—Hydrarg. ammonio-chloridi, ℈j ;
Unguenti adipis, ℥j.—M.
S. Apply with a camel's hair pencil to auditory canal, once or twice daily.

Another stimulating ointment is as follows:—

R.—Hydrarg. chlor. mitis, ʒj ;
Ung. zinci oxidi, ℥j.—M.
S. Apply to the external ear thoroughly, twice or thrice daily.

Acute Phlegmon.—Wilde[1] has mentioned a form of simple phlegmon of the auricle caused by the sting of insects, which, however, does not appear to demand treatment. Rau[2] has described an idiopathic form of acute phlegmon of the auricle, which, running a severe course, with systemic derangement, rigors, etc., terminated in suppuration.

Chronic Phlegmon.—A chronic phlegmon of the auricle has been described by some writers as terminating in cancer. It is characterized by a circumscribed hardening at some part of the auricle, usually the tragus or lobule, which gradually spreads, producing hypertrophy and degeneration of the entire auricle, with thickening of the skin, lymphatic exudation, and after years of suppuration the auricle is at last destroyed. In some cases death has supervened as the result of exhaustion from this disease.[3] The auricle may become very large, as shown by Krügelstein,[4] as quoted by Rau, who believes this disease is an insidious form of cellulitis, with secondary sclerosis of the skin, occurring in unhealthy subjects. The description suggests epithelioma.

[1] Diseases of the Ear, Phila., 1853, p. 169.
[2] Ohrenheilkunde, Berlin, 1856, p. 163.
[3] See Rau, op. cit., p. 164   Wepfe., Grundriss der Chirurgic Operat, Nürnberg, 1825, p. 118.   Conradi, Surg. Experiences, Berlin, 1830.
[4] Ueber den Krebs am Ohr. Allg. Med. Annalen des 19 Jahrhunderts, 1827, p. 145, 152.

Treatment.—The treatment must be alterative, and if considerable hardening and hypertrophy of the auricle exist, it may be necessary to amputate, which has been performed successfully by Fischer.[1]

Circumscribed Inflammation of the Cellular Tissue.—Circumscribed inflammation of the cellular tissue of the auricle occurs in the form of boils.

In the impoverished system they may become carbuncles and produce permanent deformity of the pinna.

A chronic attack of boils in the *lobule* has been noted by the author in a medical friend. These have occurred for years, but have rather decreased in frequency since an attack of typhoid fever. There has never been any deformity nor loss of substance in the lobule, a rather curious fact when we remember the large amount of suppuration that has occurred from the small affected spot.

The matter discharged from these boils, which usually discharged themselves on the posterior surface of the lobule, had a peculiar odor resembling that of Valerian.

Cornu Cutaneum Auriculæ.—Horny growths are occasionally found upon the human auricle.

Dr. A. H. Buck[2] observed a case of this nature in January, 1871 ; it was a blunted horn-like protuberance, three-fourths of an inch long, and nearly as broad at its base ; it sprang from the upper and posterior part of the left helix. It was whitish in color at its base, but gradually grew quite brownish at its summit, which was more or less jagged in appearance.

It was distinctly striated, the markings running in a slightly divergent direction from the summit to the base. At the extremity and in the middle portion it was hard like horn, but near the base it could be easily compressed, though yet comparatively hard. The line of demarcation between the growth and the normal skin was very abrupt. It was not a source of pain to the patient, nor was there any tenderness on pressure.

The growth was cut off, by two incisions along either side of

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[1] Rau, op. cit., p. 167.
[2] Transactions of Amer. Otolog. Soc., 1871, pp. 18–19.

the base, the fresh edges approximated, and the wound dressed with lint. Union took place by granulation, and at the end of the third week scarcely a trace of the operation was visible.

I saw, some time since, in the Philadelphia Infirmary for Diseases of the Ear, a case of horny growth on the upper and outer portion of the helix of the left ear, in a large, strong man, forty-five years old, whose occupation obliged him to expose himself to all kinds of weather on the river. The growth was smaller than that described by Dr. Buck, and was not discolored on its outer edge.

It caused no annoyance, but the patient had commenced to pick it and it was growing larger, when the man disappeared from observation. The middle ear on the same side was affected by a chronic purulent discharge, of slight amount.

Secondary Syphilitic Eruptions. — In a monograph on syphilitic diseases of the ear, Prof. Gruber says he has never met with a primary sore in any part of the ear. He has, however, frequently seen secondary eruptions on the various parts of the ear, and has observed that particular portions of the external ear favor certain forms of eruption, as, for example, the point of insertion of the auricle and the lobule is most liable to a papular eruption, while the other parts of the auricle most frequently show an exanthematous eruption. Squamous eruptions, too, are found on the auricle, rather than in the meatus. These diseases of the auricle do not, however, interfere with the hearing to any marked extent, and belong rather to the province of dermatology. Syphilitic ulcers and warts on the auricle I believe are rare. They are certainly not often recognized and described.

Tubercular Syphiloderm. — An infiltration of the syphilitic materies may be diffused throughout the skin of the auricle, or it may occur in the form of tubercles, varying in size from that of a split pea to that of a cherry. The latter may coalesce and thus form a general infiltration. The posterior part of the auricle is more likely to be attacked first than any other point, the spot most liable being the point of junction between the auricle and the head. This disease manifests itself any time after the first year of the inoculation has passed. It is most

apt to occur in from two to ten years after the primary sore.   I
have recently observed a case of this disease of the auricle
under the care of Dr. L. A. Duhring.   In this instance, there
first appeared a circumscribed, infiltrated lump on the posterior
surface of the auricle, which gradually increased, until it has
diffused itself throughout the tissues of the pinna.   It was
slightly elevated above the general surface of the auricle, of a
deep reddish color, painless, and there was no itching in the
growth; the latter was inclined to run a slow course.   In the
space of a month or six weeks, the infiltration had diffused
itself throughout the greater part of the auricle, and somewhat
over the mastoid portion.   The thickening and deformity of
the auricle had become considerable, the groove behind the
auricle was obliterated, and the appendages assumed a firm,
thick feeling.   This condition lasts for some weeks, then soften-
ing and ulceration ensue, the latter beginning in some natural
groove or depression.   The ulcer varies in size, shape, and depth,
its base is reddish and covered with a yellowish or grayish
puriform matter.   The rate of ulceration varies according to
the general condition of the patient; the auricle may be de-
stroyed in the course of a few months.   There is still no pain,
the discharge is more or less offensive, usually the latter to a
marked degree.

Differential Diagnosis.—This disease of the auricle is to be
diagnosed by its history and by other manifestations of syphilis
in the skin elsewhere, as alopecia, tubercles in the skin, scars,
and a general syphilitic cachexia.   It might be confused with
epithelial cancer, from which, however, it may be known by its
history, course, and objective symptoms.   In the cancerous dis-
ease there is ulceration at the outset, whereas, in syphilis, there
is first the well-marked deposit and subsequent ulceration.   In
cancer, there are well-marked everted edges to the ulcer; in
syphilis, there are none.   The secretion will offer another point
of differential diagnosis, since in cancer it is thin, watery,
bloody, and scanty, whereas, in syphilis it is thick, yellowish,
and copious.   In cancer, furthermore, there is pain, while there
is none in the syphilitic ulceration.   The odor in syphilis is
more offensive than in the cancerous disease.   In the latter
affection, the ulceration spreads peripherally from a single
point; in syphilitic ulceration the breaking down is apt to

occur at more than one point. It may always be known from eczema by the presence of deeper ulceration. Syphilitic ulceration might be confounded with lupus vulgaris, from which, however, it is to be distinguished by the history, lupus being more chronic, and the ulceration occurring at various points over the surface, but unattended by discharge. In lupus, a patch of varying size, from that of a pea to that of a small coin, first appears, being covered with small papules and tubercles from the size of a pin-head to that of a split-pea. These, in time, break down, and slowly ulcerate, are accompanied by a slight crusting and scaling of the epidermis, and characterized by marked cicatricial tissue.

The treatment, of course, is indicated by the syphilitic nature of the disease.

Idiopathic Herpes Zoster Auricularis.—At the end of inflammatory processes in the deeper structures of the ear, groups of herpetic vesicles and pustules appear upon the auricle or very close to it. These may be regarded, in a general way, as favorable symptoms, since they usually appear at the termination of disease in the deeper parts of the ear. In the same way, herpetic patches appear on the auricle in cases of widely diffused facial herpes. But an altogether different state of things is found in cases of idiopathic aural herpes, which is developed only on the structures of the ear.[1] According to Prof. Gruber, this disease belongs to the greatest of rarities, for in 20,000 cases of diseases of the ear, he has observed only 5. This disease attacks not only the parts of the organ of hearing supplied with true skin, but recently, Prof. Gruber has observed two cases in his clinic, in which, most probably, the herpetic disease extended to the drum-head and the cavity of the middle ear.

Herpes zoster auricularis, like herpes zoster in other parts of the body, manifests itself as an acute skin disease, accompanied by fever, and is characterized by the formation of vesicles and bullæ, which appear in groups and are attended with severe pain.

[1] Die Bläschenflechte am Ohre., Monatsschr. f., O., Mai, 1875, by Prof. Gruber.

The *pain* in these cases of aural herpes exists usually many days, sometimes as long as two weeks, before the eruption occurs.

In a case which came under my observation, recently, the patient stated that he was liable to severe earache and pains about the ear, which always terminated in a week or ten days by " an eruption of blisters," which I fully verified during one of his attacks. In this case, the eruption was confined to the meatus and tragus.

The pain is not always limited to the spot where at last the vesicles appear, but spreads out in different directions from the eruptive spot.

Nerves Implicated.—According to the investigations of Gruber, the nerves affected are the auricularis magnus, from the anterior branch of the third cervical; the auriculo-temporal, from the third branch of the trigeminus. He further states, that severe pain is usually complained of along the side of the neck and auricle, and the eruption appears much more frequently on the anterior surface of the auricle than on the posterior surface or in the auditory canal. Even in these favorite spots the vesicles and bullæ are more numerous in the tract supplied by filaments of the auricular branch of the pneumogastric nerve, and thus can be explained the fact that the eruption is more copious on the superior and anterior surface of the auricle than in any other part of it, and also why the posterior surface of the auricle remains almost entirely free. Perhaps the disease stands in close relation to fibres of the sympathetic connected with the nerves already mentioned as implicated in this affection, as was suggested by Gruber.

The cause of this disease of the external ear is most probably due to that which produces the disease in other parts of the body, viz., impoverished blood and consequent depraved innervation.

Symptoms.—Fever precedes the eruption, and in the graver cases may continue after the eruption has made its appearance, for the latter may come on in crops, with intervals between them. In one case given by Gruber, the fever continued thus twenty days in spite of all that was done. The crops of vesicles may succeed each other at the same points on the auricle, and the latter set will prove the most painful, since they produce deeper ulcers.

The skin of the helix and of the fossa navicularis is most likely to be attacked with the severest eruption. While herpes of the auricle does not present any features of difference from that of the disease elsewhere on the surface of the body, it has decidedly peculiar features when found in the auditory canal.

When herpes appears in the *auditory canal*, the hearing is diminished and subjective noises are heard. The hearing returns slowly after all the herpetic symptoms have disappeared. The membrana tympani is affected in some cases, according to Prof. Gruber, and then the deafness is great, and there is great sense of constriction in the head. After the vesicles rupture, the disease amounts to superficial otitis externa diffusa. Prof. Gruber has scarcely a doubt that herpes occurs in the mucous membrane of the middle ear, basing his supposition upon the views of Bertholle[1] on herpes of the soft palate.

The *prognosis* of herpes zoster auricularis is favorable. While the ulcers left by it on the auricle may last for many weeks, the usual duration of the disease in its ordinary phases is from two to three weeks.

Previous to the publication of Prof. Gruber's paper on herpes auricularis, Dr. J. Orne Green, in a paper on "Neuralgia in and about the Ear,"[2] alludes to a case of herpes zoster of the small nerves supplying the helix, which he observed in a patient of Dr. H. F. Damon. "There was a well-defined herpetic eruption over the anterior surface of the helix, which had been preceded for some days by considerable remittent pain in that part, which disappeared on the appearance of the eruption; in a few days the vesicles dried up and the disease had subsided."

He also alludes to herpes zoster of the nerves supplying the tragus and meatus, and quotes from the case of zoster of these parts published by Dr. Anstie:[3] "The disease began with acute pain in front of the tragus, recurring regularly four times in the twenty-four hours, and darting up into the meatus, the maxillary articulations, and on the side of the head; there was no tenderness on pressure or abnormal appearance in the ear; a *point douleureux* existed just in front of the tragus. On the ninth

[1] Herpes guttural en général. etc. L'Union Méd., 65, 68, 70, 1866.
[2] Transactions American Otological Society, 1874.
[3] Practitioner.

day the pain began to diminish, and on the thirteenth, herpetic vesicles appeared on the auricle, which from irritation became ulcerated and very susceptible to cold, which set up the old neuralgic pain; on the twentieth day all symptoms had disappeared."[1]

Herpes Zoster of the Tragus.—I recently saw in a young lady, 18 years old, under treatment for slight pruritus of the external auditory canals, a very well-marked instance of herpes zoster of the right tragus. Sharp pain for several days, quite intense at times, preceded an eruption of vesicles, which finally became pustular, and then desiccated, without forming ulcers. The patient was pallid, though apparently strong and active.

Treatment.—The treatment of this disease consists in the greatest attention to the general condition of the patient, and in local applications which will tend to prevent destruction of the deeper parts. Preservation of the vesicles is much more easily accomplished on the auricle than in the auditory canal.

In the latter region, the tendency appears to be not to form crusts, but the vesicle soon bursts and a purulent discharge is then set up with considerable pain. In such a case, Gruber uses a solution of sulphate of zinc.

In a second instance of this disease in the auditory canal, the same observer punctured the vesicle, leaving the epidermis as a protective covering; but even in this case the treatment had to be supplemented by the use of solution of zinc.

Artificial opening of the bullae on the auricle appeared to be followed by a much better result. The small, shallow ulcers, which form in the latter case, are cured by the use of simple cerate. Where the pain is great, diachylon salve, to which tincture of opium is added, has been found of the greatest benefit; the salve being smeared on linen and applied to the inflammed spots.

The treatment recommended by Dr. Anstie in the case referred to (p. 236) consisted in hypodermic injections of one-sixth of a grain, twice daily, in the region of the auriculo-temporalis, protecting the painful external parts from the air by coating them with collodion, and the painful parts of the auditory canal by

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[1] J. O. Green, loc. cit., p. 569.

means of warm simple ointment or tallow, keeping the meatus
closed by cotton. He also thinks counter-irritation, by means
of mustard or cantharides over the occipital triangle, might
prove beneficial by reflex stimulation.

CHAPTER II.

MORBID GROWTHS AND INJURIES.

MORBID GROWTHS.

THE auricle may be the seat of various morbid growths, such
as cysts, angioma, vascular nævus, fibrous tumor, sarcoma, and
epithelial cancer.

New formations of cartilage sometimes appear after frost-bite
of the auricle, giving origin to numerous small, hard, and sensi-
tive nodules, which may be both seen and felt throughout the
cartilaginous structures of the pinna. (p. 225.)

Cysts.—The simplest growth on the ear is a cyst. That
form of primary cyst known as *atheroma*, developed in the
subcutaneous tissues, may attain a very large size, in some in-
stances reaching a diameter of several inches. Its growth is
slow; in the concha there may be found the variety known as
sebaceous tumor. In both forms, inflammation may occur, and
a natural cure ensue.

Treatment.—These growths should be extirpated by the knife,
and their sacs cauterized.

Angioma.—Angioma or the formation of new vessels, espe-
cially the cavernous variety, may be found in the auricle. The
origin of such a growth may be in the auricle, or may spread to
it from neighboring tissues. These growths may present re-
markable as well as threatening appearances in some instances,
as has been shown in a case related by Dr. Chimani.[1] In this
instance the tumor first showed itself, shortly after the birth

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[1] "Aneurisma cirsoideum." See Blake's Report: American Otological
Society, 1874.

of the patient, a strong, healthy boy. The new growth was at first 2 cm. in diameter, in front of the left ear, and of a soft consistence and bluish color. By the time the patient was five years old, the tumor had become as large as a walnut, from which time until he was fourteen years old the growth increased rapidly in size, and one year later, when brought to Dr. Chimani, at the Military Medical School of Vienna, the Josephenum, the tumor included the greater portion of the left half of the scalp, was soft, elastic, slightly fluctuating, painless, pulsated distinctly, and could be diminished in size by pressure. The skin covering it was bright red, and of a higher temperature than the surrounding parts.

Angioma of the lobule only, has been observed and reported by Dr. Charles J. Kipp.[1] In this instance the growth occupied the left lobe of a man fifty years old, and seemed to have been caused by a frost-bite of the ear, twelve years previous, at which time he noticed a bluish spot on the outer side of the lobule of the left ear.

Vascular Nævus Maternus.—That form of vascular growth known as "mother's mark" may involve the auricle, together with parts of the adjacent check and neck. In a negress thus affected, the lobule and lower half of the helix were especially large and liable to engorgement, while the general appearance of the auricle was elephantine and grotesque. All such vascular growths are painless, but are liable to feel hot and heavy after exercise. The rest of the auricle may be somewhat hypertrophied, and if the growth invade the external auditory canal, the hearing will be impaired. Their vascular nature is very apparent by their color, their temperature, and compressibility, as well as by the pulsation which may be felt with more or less distinctness in all of them, and by the murmur which may be heard in some of the larger ones, as in the case reported by Chimani. In the latter instance the subjective symptoms were aggravated by the fact that the auditory canal was greatly implicated in the growth. There were headache, hardness of hearing, tinnitus aurium, and sensations of heat and beating on the affected side.

Treatment.—The treatment of these vascular growths must

[1] Transactions American Otological Society, 1875.

always be modified by their position in or about the auricle. and by their size.

The treatment of angioma of the lobule of the auricle is comparatively simple, but treatment of larger growths involving the entire auricle and surrounding parts, and extending into the auditory canal, becomes of the greatest importance. It is even questionable whether heroic measures are ever justifiable in the latter instance.

In removing angioma of the lobule, the method followed by Dr. Kipp[1] is probably the best. I have used it with slight modifications, with entire satisfaction. It is to fasten the lobule in an ordinary entropion forceps, to control the hemorrhage, and then make an incision parallel and close to the lower border of the lobe. The skin should then be dissected off the tumor, and when the latter is fully exposed, the knife should be carried behind it, and its connection with the subcutaneous tissue severed. Healing by first intention usually ensues, and the lobule heals without any deformity.

For the cure of angioma, especially the larger forms, Gruber[2] has recommended various forms of cauterization, vaccination, the application of diachylon plaster and tartar emetic ($\mathfrak{z}$ij–gr. xviij),[3] the subcutaneous injection of liquor ferri sesquichlorati, and acupuncture. He gives the preference, however, over all these, to rapid extirpation of the new growth, and in order to prevent the necessarily copious hemorrhage, recommends ligation of the large vessels supplying the parts or the use of the galvano-caustic.

Subcutaneous injections of chloride of iron were used by Chimani in the case referred to, with moderate success, but not enough to warrant the risks of inflammation and hemorrhage. The danger of the latter, as well as of sloughing, should deter the surgeon from adopting any form of treatment which would be likely to produce such results.

Fibrous or Fibro-sarcomatous Tumors of the Lobule.— Tumors of various sizes have been found on the lobule as the result of piercing this part of the ear for the purpose of wearing ear-rings.

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[1] Loc. cit.   [2] Op. cit. p. 409–410.
[3] Zeissl: quoted by Gruber.

Gruber states that he has seen two cases in children, in whom small tumors, the size of a pea, appeared on both sides after the piercing of the ear several years before. In his opinion these tumors had originated from granulations which, springing from the hole in the lobule, had developed on their free surface skin and then become stationary. These tumors are composed, according to Billroth, of spindle cells and connective tissue.

A similar variety of tumor has been observed among negroes, by several writers,[1] and is attributed invariably to wounds inflicted by the piercing of the lobule, or the tearing consequent upon the enormous rings the lobule is obliged to support.

Some years ago, I observed two large tumors of this variety in a young and very fat negress (mulatto). There was no history of the lobules ever having been torn by the weight of her ear-rings, which were very large, nor of any wounding of the parts by the act of piercing. In this case it seemed that the growths had been brought about by the weight of the ornaments.

One tumor was as large as, and shaped like, an English walnut, with a large chestnut laid on it, and the other tumor was as large as the largest chestnut. I removed both tumors, and exhibited them at the Pathological Society of Philadelphia, where, in the remarks which followed from the members, it appeared that these tumors of the auricle, apparently produced by the improper wearing of ear-rings, had often been observed in this city, in negroes, and that they had usually grown again after removal, but the subsequent growths were just as benignant as the first. Their microscopic character was similar to that given by Billroth to the tumors described by Gruber. This peculiar tendency to benignant recidives has also been noted by Dr. R. F. Weir, of New York City; Dr. Bertolet, of Philadelphia, and many others.

Sarcoma of the Lobule.—M. Roudot[2] has described a case of sarcoma of the lobule, in a peasant woman 42 years old. The tumor occupied the right lobule, was soft and ovoid, 5 mm. long,

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[1] Langaard, Wiener Med. Wochenschrift, 1869. M. J. Bramley, Transactions of Medical Society of Calcutta, vol. vii., Saint-Vel, Gazette des Hôpitaux, 1864.

[2] Gazette Méd. de Paris, 1875, No. 26.

3½ mm. broad, and 8 mm. thick. It grew very slowly for twenty years; during the patient's fifth pregnancy, it developed very rapidly and included the entire lobule. The tumor appears to have been painless, for the most part, but sometimes during her menses the patient would complain of a burning pain in the auricle of the affected side.

In addition to the entire lobule, the tumor also included part of the tragus. The new growth was reddish and flat, with some eroded spots; on the hinder edge there was a pretty large ulcer: a second, smaller ulcer extended from the under part of the tragus out upon the skin of the cheek. The organ of hearing was otherwise normal, and there were no glandular enlargements. The lobule, together with a small part of the tragus, was amputated, and the wound did well for several weeks, when the patient voluntarily left the hospital.

Glandular Hypertrophy of the Lobule.—After inflammation of the skin of the lobule of the auricle, there may remain a chronic hypertrophy of the glandular structures, of a nature similar to those chronic enlargements met with in the cutaneous structures elsewhere in the body, after being invaded by inflammation. This is fully illustrated in the following case:—

Bridget G., age 22 years, a seamstress, states that at thirteen years of age she had an attack of erysipelas of the scalp, which involved the auricle to a marked extent. The auricle remained inflamed for six weeks, but then gradually lost all swelling, excepting at the lobule, which has remained about twice the natural size ever since. There has never been any return of the erysipelas of the scalp. At the time of first examination, the lobule, besides its enlargement, presented a livid, reddish hue, was shiny, scaly, slightly erectile when manipulated, but not sensitive. Its surface usually presented a flaccid appearance, like a partially withered grape.

Treatment.—The under cutaneous edge of the lobule was dissected up for a quarter of an inch, and then a V-shaped incision was made, including the growth on the lobule. There was considerable bleeding from two or three spirting arterioles, which was finally controlled by ice. The edges of the cut were held together by a stitch; the wound healed by first intention, and without a trace of the incision.

The tumor thus excised, I submitted to Dr. Morris Longstreth, Pathologist to the Pennsylvania Hospital, in Philadelphia, who has kindly made most skilful sections, and written the following descriptions of the microscopic appearances of the tumor:—

" The tumor shows varied histological and histioid elements ; the preponderating constituent is an ill-developed epithelial cell, resembling the squamous variety and having a great diversity of outline.

" First of all can be shown the elements of normal skin, the papillæ with the covering corneous layers, and the hair-bulbs. There can be seen, in the deeper parts, the subcutaneous connective tissue, in which in places the vessels are large and numerous ; around these vessels the fibrous tissues are denser and more abundant than usually seen in these parts ; this fibrous tissue forms a sheath to, or a canal in which, the vessel is distributed. In and around the sheaths of the vessels are seen, in many places, deposits of adipose tissue, arranged in lines parallel to the main trunks and also following some of the smaller branches. So far, the appearances shown in the microscopic sections correspond to the normal histological elements of the skin, the papillary layer and the hair-bulbs seem normal, whilst the deeper layers are hypertrophied or hyperplastic ; the connective-tissue parts appear overloaded or crowded with granular (or cellular) elements. No distinct cells can be isolated here, and the structure altogether presents a very confused picture.

" Between the dermic layers and parts further removed from the surface (viz., the parts which seem to constitute the tumor-mass proper) is a defining line ; the line is not constituted of a bounding or limiting membrane, such as to be described as a capsule or basement-membrane ; but there is to be seen a distinct differentiation of the one part from the other. This condition is well marked in some specimens.

" The inner area shows the same confusion or want of distinctness of arrangement. The cells approximate likewise to an epithelial type ; some appearing like ill-formed or undeveloped squamous epithelial cells ; others resembling young nuclear (embryonal formative) elements found in the lower strata of all membranous tissues ; others again have the shape of columnar cells (perhaps this form may be due to close packing) ; still

others appear of an elongated or fusiform character, or else as rounded cells of small size with bipolar filiform appendages of great tenuity. In all this inner area there is no trace of blood-vessel structure, nor of a stroma or intercellular network. There is no appearance of stroma of any kind, save that of the filiform cell-appendages.

"The nuclei of all these cells are of small size, and in a majority of instances so obscured by granular or fatty elements as to be scarcely visible. In some instances the cell-shapes, but not the cell-arrangement, approximate to that of the small spindle-celled sarcoma. This character cannot be maintained as the nature of the growth. There is no one type presented in such a degree as to lead to the classification under any histioid group.

"The only solution which presents itself, and that a problematic one, is that the new growth belongs in the main to the glandular structure, and with this has taken place a (sarcomatous?) growth in the surrounding connective tissue; that, under the erysipelatous irritation to which the lobe of the ear was subjected, in the first instance, some one or more of the glands became ectatic from the swelling and closure of the duct; and that, instead of its contents undergoing the accustomed degeneration, the consequence of the erysipelatoid hyperæmia, started by the erysipelas and maintained, in part, by the ectasy of the gland, there ensued an hypertrophy or hyperplasia especially of the underlying, more than of the superficial tissues. In other words, we have taking place an inflammatory new formation, in which especially participates the connective tissue, and this new-formed connective-tissue element has maintained, to a high degree, its hypervascular character (even to becoming somewhat erectile); and that, in this new growth, mixed elements share in the occupation of the territory; on the one hand, cells which present a type tending to the epithelial character, on the other hand, coming out more conspicuously in the deeper parts, cells which in the fusiform character, verge towards the embryonal cells of a connective-tissue growth and give appearances calling to mind the sarcomatous new formation.

"There is, however, another element or character present which I cannot wholly pass over, viz., the glandular element. Not only is there to be seen the passing by insensible gradations from the papillary layer in what we may regard as a part purely,

or nearly so, of subcutaneous connective tissue (however much this may be changed by overcrowding of cells), but this again passes over into an area of cells in which there can be seen no stroma cells, some of which are columnar in character, that may well be held to have to do with the recess of a gland in the condition of ectasy. The only supposition under which the glandular participation in the new growth, as a whole, is tenable, is that the gland elements, and especially their secretion, under the influence of the permanently increased hyperæmia, did not tend, as is their wont, to retrograde metamorphosis, in spite of the gland becoming ectatic and thereby retaining its secreting contents. Also, it must be evident that the inflammation-disturbances have something to do in producing a permanent alteration in the function of the affected glands—not a very difficult supposition, and quite within the range of experience."

Epithelial Cancer.—Epithelial cancer of the auricle has been described by Gruber,[1] Wilde,[2] Kramer,[3] Toynbee,[4] Demarquay,[5] J. Orne Green,[6] Gustav Brunner,[7] T. Bryant,[8] and others.

It is said by Gruber to be the only malignant disease which occurs in the auricle primarily. It generally appears as a small nodule or wart in the skin of the auricle, which, being picked at in most cases, soon is found to be covered by yellowish scabs, the result of the hardening of a scanty discharge from the new growth. Beneath these crusts there is found an ulcer, with a not very rough base, somewhat disposed to bleed, and the edges of which are hard and uneven. After a rather slow destruction of the superficial tissues, the deeper structures of the ear may be invaded. The auricle may be destroyed in this way, and then the deeper parts of the ear become the seat of the cancerous disease. There is usually some pain, but it is not invariably severe; in some cases, however, it may be intense, as shown by Brunner.

[1] Ohrenheilkunde, p. 416.   [2] Diseases of the Ear, p. 208.
[3] Op. cit., p. 204, quotes Fischer, 1804, "Krebs am Ohre," and Krügelstein, 1827, Allg. Med. Annalen des 19 Jahrhunderts.
[4] Diseases of the Ear, p. 24.   [5] Gazette des Hôpitaux, Sept. 30, 1869.
[6] Transactions American Otological Society, 1870.
[7] Archiv f. Ohrenh. Bd. v. p. 28.
[8] Med. Times and Gazette, London, Jan. 6, 1872.

Wilde alludes to *chimney sweep's cancer* of the external ear, which is, however in no way peculiar excepting as possessing large amounts of pigment.

The *chronic inflammation of the cellular tissue* of the auricle, alluded to by Kramer, is in all probability a description of cancerous degeneration of the appendage.

Epithelioma of the auricle may interfere greatly with the hearing, the interference being proportionate to the advance of the disease into the auditory meatus. I have seen but one case of this disease in the auricle, and that occurred in a negress, fifty years old.

She stated, when I first saw her, that the growth on the ear was about six months old, and had been caused by a blow on the auricle, from her son, with a loaded cane. I found the meatus almost entirely occluded by the growth, which appeared to have started from the region of the tragus, and had progressed rapidly inward, on the superior wall of the auditory canal, producing also some induration outward toward the zygoma, its entire size being about that of a small English walnut.

The discharge was bloody and purulent, several drachms daily in amount, not very offensive, but of a peculiar odor. The ulcerated surface of the tumor pointed inward, filling up the auditory canal. The hearing was reduced to almost nothing. There had been no disease of the ear, previous to this, according to the woman's statement, which appeared to be reliable in all respects.

Excision of the growth was advised, as it had grown rapidly from a well-defined centre, but the patient refused, and soon after disappeared entirely from my notice.

Dr. Gustav Brunner,[1] of Zurich, observed a case of primary epithelial cancer of the ear, in a female 56 years old, which proved fatal in the course of the year.

The health of the woman had been good up to the time when a slight discharge came from the ear; previous to this there had been some itching in the ear, and she had scratched the organ with a hairpin, but there had been no deafness. For the slight discharge, she subjected herself to some kind of water-

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[1] Archiv f. Ohrenh., Band v. p. 28.

cure douche on the ear, and this was followed by intense earache
and facial paralysis. Granulations in the mean time sprang up
in the ear, which upon manipulation bled freely ; pain in the
ear became intense and constant, and, as on consultation with
Prof. Billroth, Dr. Brunner concluded that the morbid growth
had already reached the inner wall of the tympanum, no
operation was advised. The ear was kept carefully cleansed,
and the pain was eased by anodynes as far as it was possible.
The auricle was at last dissected loose by the disease, and at
several spots about the ear there was loss of substance. There
was no post-mortem examination permitted.

In the early stage of this case, pain was the chief diagnostic
difference between it and one of polypus or granulations in the
ear. Microscopic examination of a piece of the granulating mass
in the meatus revealed the true malignant nature of the growth.

Treatment.—The only beneficial treatment of epithelioma of
the auricle is immediate excision of the growth, even if to do
this it is necessary to amputate the entire pinna, as was done
by Dr. Thaxter, in the case reported by Dr. J. Orne Green.[1]
The hemorrhage which must naturally occur is to be controlled
in the ordinary way by ligatures.

Healing may be slow, and in those cases in which the entire
auricle has been cut off close to the skull, the granulations must
be closely watched and prevented from closing up the external
auditory meatus. This is best done by keeping some form of
tent in the opening of the canal and by touching the granula-
tions with caustics or by stimulating washes. The treatment
will be eminently successful if the cancerous disease has not
extended to the meatus and the drum ; in the latter instance
the disease may have advanced too far to be controlled by
surgical interference.

Othæmatoma.—Othæmatoma, or blood-tumor of the ear, is
characterized by congestion and heat in the auricle, and a rapid
effusion of blood between the cartilage of the auricle and the
perichondrium. The tumor, in the course of a few hours or a
day, attains the size of a bean or an egg, the color of the auricle
may remain natural or become purplish, and though the tumor

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[1] Loc. cit.

is somewhat hot and dense, fluctuation can be detected in it. There is some burning pain in the new growth, with a feeling of weight and distention. The earliest manifestations of the disease are rapid, but after the tumor is fully formed, it may remain apparently indolent for days or even weeks. At last it may rupture spontaneously, the most frequent mode of disappearance, or its contents may coagulate and absorption without rupture take place, causing considerable permanent deformity, but much less than when the tumor ruptures spontaneously or is punctured artificially.[1] Its occurrence is more frequently unilateral than ambilateral, but an attack on one side may be

Fig. 62.
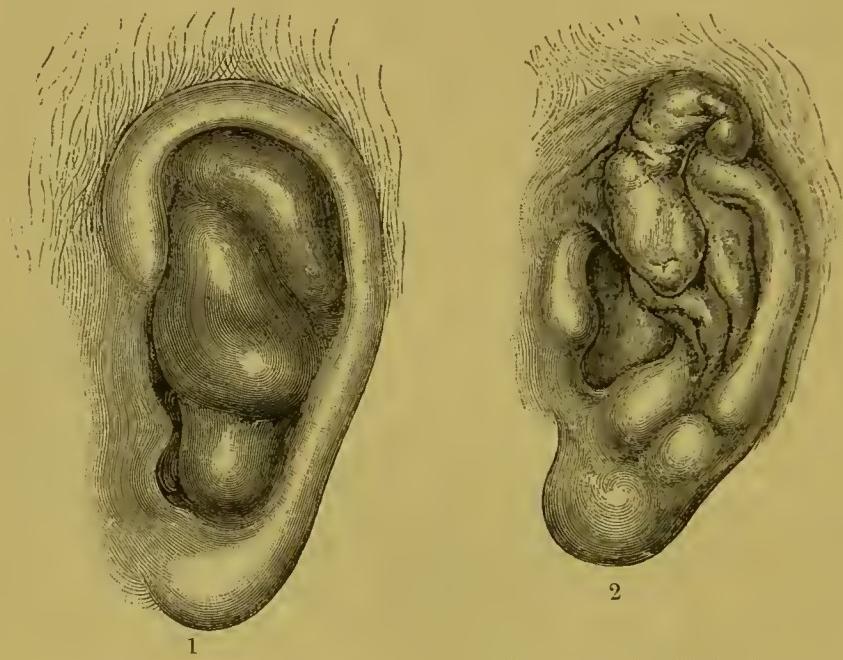
Othæmatoma 1, and the Resultant Deformity 2. (Gruber.)

followed by an attack on the other,[2] the lobule is never attacked in this disease of the ear. In an account of twenty-four cases of this disease, by E. R. Hun,[3] sixteen were unilateral, but in four cases the disease on one side was succeeded by the disease

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[1] E. R. Hun; American Journal of Insanity, p. 23, 1870.

[2] Laycock, case of Othæmatoma under care of Mr. J. Hutchinson, Med. Times and Gazette, Dec. 1862, p. 603.

[3] Op. cit., p. 17.

on the other, the first hæmatoma subsiding usually before the second ear was attacked.

The disease is more common in males than in females, only one of the above twenty-four cases being of the latter sex. Dr. I. Ray has informed me that he has never seen this disease in females, whereas he has constantly met it in males. He furthermore states to me, that, when in charge of insane asylums, he has constantly had cases of othæmatoma on hand, two or three at a time in old cases of chronic dementia, a noticeable feature of whose malady is their entire harmlessness and docility. So great is this latter characteristic, that they are made kind of under-nurses in the asylum, which fact would tend to prove that the disease in them is caused neither by blows nor falls, as they are not likely to be struck by others, and are perfectly able to take care of themselves.

Etiology.—This disease of the auricle has been the subject of great discussion, as to its cause, nature, and significance. Formerly it was considered entirely the result of violence, but later writers have denied its purely traumatic origin, and have given to it an important significance, inasmuch as they have described an idiopathic variety occurring most frequently or only in the insane,[1] asserting as its cause a disease of the brain, some authorities even localizing the exact seat of the cerebral disease in the restiform bodies.[2] Others, while admitting its most frequent occurrence in the insane, still cling to the idea of its purely traumatic origin, being of the opinion that the weakened and often helpless condition of the insane, renders them most liable to violence to the auricles.[3]

In all probability there are two[4] distinct forms, the purely *traumatic* and the purely *idiopathic :* the first seen in well-known cases of violence to the auricle, as in boxers, and the insane who have been beaten by their keepers, themselves, or each other; and the second, so frequently seen in the paralysis of the insane, and in diseases of the restiform bodies as proven by experimental irritation of them in rabbits. Even in cases of insanity where

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[1] E. R. Hun ; American Journal of Insanity, vol. xxvii. 1870.

[2] Brown-Séquard, Lecture in Univ. of Penna., Oct. 10, 1872.

[3] Thurnam and Toynbee ; Toynbee on the Ear, London, 1868, p. 21. Von Troeltsch, English Transl. 1869, p. 50.

[4] Gruber, Lehrbuch der Ohrenheilkunde, Wien, 1870, p. 281.

the latter variety is found, the first variety has been observed too, but the difference of the two forms is very apparent. It is also asserted that the purely idiopathic variety has been observed in the perfectly sane.[1] Both Schwartze and Wendt have observed such cases.[2] But even granting that at the time of the occurrence of the othæmatoma in these cases the subjects were sane, they certainly presented grave symptoms, for their malady could but be regarded as indicative of disease of the brain, which had not yet, 'tis true, culminated in insanity,[3] but which would render their future sanity very problematical. "When we consider the intimate connection between the circulation in the ears and that of the rest of the head, we cannot but acknowledge that any disturbance in the circulation in the brain is prone to produce a corresponding alteration in the circulation of the ears. Now, in all chronic cases of insanity, and especially in general paresis, we find a tendency to repeated congestions of the head, and under such circumstances it is natural to suppose that the bloodvessels of the ears become gradually dilated, so as to favor the occurrence of an effusion of blood."[4]

"It is," says Dr. Hun, "idiopathic, depending upon a pathological condition of the brain, and is incapable of being produced by violence alone."[5]

Some of the earliest writers on this disease called it erysipelas of the auricle; but of course that view was erroneous. This disease may make its appearance on the posterior surface of the auricle, though rarely,[6] and is called by Kramer[7] a perichondritis of the auricle. This author also asserted its frequent occurrence in the insane, but very rarely in others. He, however, states that Langenbeck had seen two cases in the sane, and Heyfelder one case in a healthy miller, in whom the tumor occurred with pain after epistaxis for several days.[8]

[1] Roosa; Treatise on Diseases of the Ear, two cases by Roosa, and one case by Loring; also a case by Gruber. Lehrbuch d. Ohrenheilk. p. 283.
[2] Archiv f. Ohrenheilkunde, vol. ii. p. 213, and vol. iii. p. 29.
[3] Brown-Séquard; Roosa; Treatise on Diseases of the Ear, p. 112, 1873.
[4] Hun; American Journal of Insanity, 1870, vol. xxvii. p. 24.
[5] Op. cit., p. 28.
[6] Allgemeine Zeitschrift für Psychiatrie von Damerow, 1848, vol. i.; Rau, Ohrenheilkunde, p. 167.
[7] Die Erkenntniss und Heilung d. Ohrenkrankheiten, Berlin, 1849. p. 212.
[8] Rust's Magazin, 66 Bd. 2 Heft, p. 297.

Dr. Kirkbride of the Pennsylvania Hospital for the Insane, and Dr. Curwin of the Pennsylvania State Lunatic Asylum at Harrisburg, are inclined to the opinion that othæmatoma is usually the result of violence, and almost invariably confined to males.[1] Dr. J. H. Worthington,[2] chief physician to the Friends' Asylum for the Insane at Frankford, Philadelphia, who has observed and treated a large number of cases of this disease of the auricle, has never seen a case of this affection in a *sane* person, nor in a case of curable insanity. He always considers this affection of the ear as an evidence of the incurable form of insanity, such as he has described as "congestive mania." From the observations of Dr. Worthington it appears that othæmatoma is always associated with a tendency to congestion of the membranes of the brain or the cerebral substance itself, in which opinion he is nearly in accord with Dr. Laycock,[3] who thinks "that the states of the circulation, nutrition, and development of the tissues which make up the ear, lobule, and cover the helix, very commonly coincide with similar conditions of the encephalic tissues."

That the origin of othæmatoma may be purely nervous, is proven by experimental irritation of the restiform bodies. Brown-Séquard[4] states that this variety of tumor is the result of disease at the base of the brain, and is usually found in the paralysis of the insane. It may be produced artificially in animals, and this he has done in less than one night, between the hours of ten in the evening and six o'clock in the morning. He has performed such experiments, and kept the animal *under his own eye*, until the artificially produced tumor made its appearance. This he accomplished by an irritation applied to the restiform body, on the side corresponding to that of the tumor. In these cases the process thus excited in the ear may pass rapidly into gangrene, so powerful is the effect of the irritation of the restiform body. The lecturer also drew attention to the fact that these tumors usually occur, in the insane, on that side corresponding to the affected side of the brain, which proves that they cannot be, at least not always, the result of

[1] L. Turnbull, Clinical Manual of Diseases of the Ear, 1872, pp. 138–139.
[2] Ibid.   [3] Med Times and Gazette, March, 1862, p. 289.
[4] Lecture in the University of Pennsylvania, Oct. 10, 1872.

violence on the part of the patient or his attendants; since violence of any kind would not be applied invariably to the side of the head nor to the ear corresponding to the affected side of the brain.

Dr. Yeats,[1] of the Coton Hill Institution for the Insane, England, believes that the cartilage is the seat of this affection, and that hence the lobule of the ear always remains intact. He has not found othæmatoma prejudicial to hearing; on the contrary, he has observed that the hearing became sharper in some instances during the disease. He has further observed that this affection of the ear is not confined to any particular form of insanity, although it is frequently found in dementia; that it never occurs in the sane, and that the prognosis of mental recovery in those affected with idiopathic othæmatoma is extremely unfavorable. In all his experience he knows of but one case of insanity in which recovery ensued after the appearance of this unfavorable symptom. The patient, a married female, thirty-three years old, was admitted to the aforesaid institution; thirteen months afterwards, in the midst of every variety of bad symptoms, othæmatoma appeared, and, after running its course, disappeared. Finally, the patient began to show signs of mental recovery, and was discharged from the asylum perfectly restored to reason, after three years of insanity.

With the evidence thus gained it would seem that the inevitable conclusion must be, that the occurrence of idiopathic othæmatoma is found either in the hopelessly insane, or in those about to become so from cerebral disease which has induced the affection on the auricle. The prognosis, therefore, in the case of one thus affected, becomes extremely unfavorable.

Treatment.—In the treatment of othæmatoma the endeavor must be to alleviate pain, prevent as much as possible subsequent deformity of the auricle, and to be guided in the treatment by the form of the disease, since it is manifest that surgical interference is, most usually, undesirable in the idiopathic form, occurring in the insane, but it may be demanded in the traumatic form, or in the idiopathic form, should it occur in the sane.

[1] British Med. Journal, June 21, 1873.

The pain in this disease of the auricle does not appear so urgent as to demand puncture of the tumor, at least not in the idiopathic form. It is evident, however, that if the pain caused by the distention of the parts in either form, especially in the traumatic variety, is great, it would be advisable to puncture the tumor.

Deformity is not only less likely to occur if the auricle is let alone until spontaneous absorption is brought about, but in the insane is of so little moment that the fear of its occurrence should never induce the surgeon to operate.

Dr. Hun has observed, that, in those in whom spontaneous absorption or rupture has occurred, the deformity is very much less than when the tumor has been opened by the knife of the surgeon, the least deformity occurring when spontaneous absorption is induced.

Of course the form of the disease would have the greatest weight in deciding whether we should operate by incision or not; but, although the operation would not be contraindicated in the traumatic form by the *cerebral* condition of the patient, the most satisfactory results are said to be attained in those cases where spontaneous or induced absorption occurs.

However, many prominent aural surgeons are in favor of early operation in all forms of othæmatoma. Gruber[1] gives the result of his observations, in connection with Drs. Joffe and Sehlager, as favorable to an early evacuation of the effusion, and the application of pressure to insure union in the walls of the cavity which contained the blood. The instrument he uses is a trocar if the blood is still fluid, but if it is coagulated, he incises the tumor and removes the clot. He is totally opposed to the so-called antiphlogistic treatment by the use of " Goulard's solution ;" but recommends, for the thickening and deformity of the auricle, painting with tincture of iodine.

Roosa inclines to the above treatment,[2] but Rau,[3] an author who appears perfectly conversant with all the literature pertaining to this subject up to the time of the publication of his book, is decidedly in favor of using, at the commencement of

[1] Lehrbuch d. Ohrenheilkunde, Vienna, 1870, p. 286.
[2] Roosa, Treatise on Diseases of the Ear, etc., New York, 1873, p. 111.
[3] Rau, Lehrbuch der Ohrenheilkunde, Berlin, 1856, p. 170.

the disease, cold lead-water dressings, which he advises to be used until the tumor begins to soften a little, then they are to be removed and warm fomentations of arnica are be used in order to favor resolution and absorption. He is of the opinion that incisions into the tumor are *almost always* injurious, yet they are preferable to the method of acupuncture as suggested by Speyer, for the former means removes more thoroughly the coagula. Saxe, according to Rau, recommended, after the incision and the removal of the coagula, the application of dressings of alum and water (2 drachms to fʒiv), and to cover the entire ear with cotton-wadding. As we have already seen, Hun[1] disapproves of incisions in any case of othæmatoma, and Kramer[2] approves of general roborants and cool dressings at first, until the tumor begins to soften, then absorption may be promoted by the use of dressings of tincture of arnica. But he is opposed to all incisions and surgical operations in these cases.

Dr. Kirkbride[3] has found the application of ice and tincture of iodine most highly useful; the latter may be applied twice daily. But he has not found the ear disposed in any case to resume its original shape. Dr. Worthington[4] disapproves of incisions as useless.

Othæmatoma in the Sane.—Some writers have recorded instances of what they have termed spontaneous othæmatoma in the sane; but in most instances, the cause of this disease in the sane can be traced to various traumatic influences, as boxing, and blows[5] on the auricle from many other causes,[6] burns, scalds,[7] and exposure to intense cold.[8] The more clearly traumatic cases have also been termed spurious othæmatoma, to distinguish it from the truly symptomatic variety occurring in the sane. It is most frequently observed among males, though the case reported by Dr. Blake was that of a woman 30 years old, who had been struck on the ear in falling. In this instance,

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1 Loc. cit. p. 23.
2 Die Erkenntniss und Heilung d. Ohrenkrankheiten, Berlin, 1849, p. 214.
3 See Turnbull, op. cit. p. 138–139.   4 See Turnbull, op. cit., p. 139–140.
5 C. J. Blake: Statistical Report of 1652 Cases of Ear Disease, 1872.
6 Trautmann: Cases of Ear Disease in Garrison, at Breslau, Prussia; Archiv f. Ohrenh. Bd. ix. p. 183.
7 C. J. Kipp: Transactions American Otol. Soc., 1873.
8 Gustav Bruuner: Archiv. f. Ohrenh., Bd. v. pp. 26–28, 1870.

an abscess ensued in the injured auricle, and after painful suppuration, discharged an ounce of pus.

As this disease has been noted among soldiers in a garrison, it is fair to presume that it is the result of rough sport in which they receive severe blows on the ear. Not uncommonly the traumatic variety of othæmatoma occurs among boys, receiving hard hits on the ear in playing foot ball, as stated by the late Mr. Hinton, of London.

One of the most remarkable accounts of the traumatic origin of this disease is that given by Dr. Brunner, of a man forty years old, who, in riding all night in a very cold railway car, fell asleep with the auricle against the window pane, to which, on waking the next morning, the auricle was frozen fast. The rarest instances of traumatic othæmatoma are those resulting from burns or scalds, as in the case related by Dr. Kipp. The prevalence of this form of injury among boxers is so common, that it is shown in ancient statues of noted athletes, as pointed out by Virchow.

Diagnosis.—The diagnosis will not be difficult, as the history and general condition of the patient will usually plainly indicate the traumatic origin of this variety of blood-tumor of the ear. Most of the symptoms are sthenic, whereas the asthenic and indolent character of the tumor in the insane is very marked, and hence distinctive.

Treatment.—The treatment of traumatic othæmatoma should consist in opening the sac if suppuration has ensued. But if the latter process shall not have taken place, the symptoms of heat, congestion, swelling, and pain must be combated as in the idiopathic variety, viz., by application of ice and iodine.

If it be necessary to open the sac to evacuate the pus which may have formed, the cavity should be gently stimulated by injections of weak solutions of carbolic or salicylic acid, and the walls kept in contact by gentle compresses. It will be found that with proper management the auricle can thus be kept from much deformity.

INJURIES OF THE AURICLE.

The general surgeon is often called upon to treat a variety of wounds of the auricle, but it is hardly in place to treat of them

here. Most of these are caused by quarrels, and are inflicted by weapons, blows, and bites. Those caused by weapons appear to be somewhat peculiar to the countries where they occur, as in the French soldiers, whose auricles were so frequently injured by the yataghan in the battle of Constantina;[1] in Ireland, auricles have been split and bruised by the blackthorn stick;[2] and in Germany, the student's "schmiss" is often obtained by a sword-thrust or slash at the auricle. The treatment will consist in adjusting the wounded and displaced parts, keeping them in position by a stiff dressing, and the attention to general principles of surgery.

Traumatic Cleft of the Lobule.—A not uncommon injury of the auricle is one caused by tearing out the ear-ring, and thus causing a cleft of the lobule. This is produced most frequently by children in play with their mothers, but it is also done in fights between women. I have seen lately two sisters, both quarrelsome, in whom the lobules were cleft, one in three places, making four teat-like appendages, or fringe, said to have been caused by her babes, but the other woman acknowledged that in a quarrel with a female acquaintance, the ear-ring had been intentionally torn from her ear by her adversary. In both of these women the deformity had existed for several years.

Treatment.—If such cases are seen as soon as they occur, union by first intention can usually be effected; I have never seen any but chronic cases. Dr. Knapp, of New York, has lately suggested[3] a very neat and practicable operation for removing the deformity in such cases, without leaving the notch on the edge of the lobule, so common after operations on this part.

This operation is a modification of the Mirault-Langenbeck operation for hare-lip, applied to the auricle, and consists in the following method: If the left ear is to be operated on, let the patient recline to the right side. The surgeon may stand behind the patient, while an assistant with his thumb and index finger seizes and stretches the anterior part of the lobule. Then thrust a narrow-bladed scalpel through the anterior part near the lower end of the slit (at *a*, in the

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1 Wilde, op. cit., p. 164.   2 Ibid.
3 Archives of Ophth. and Otol., vol. iii. No. 1.

accompanying figure), sever a thin slice of skin along its edge, when the other end of the slit is nearly reached (at *c*), make the slice a little broader, leave its end (at *b*) in connection with the auricle, then turning the knife, go backward about two lines, and cut across the detached slice (at *c*), thus forming a small flap. Now seize the long portion of the slice with a pair of forceps, and divide with the knife its other end (at *a*) by a slightly curved section. Without waiting long for the cessation of the bleeding, the edges of the wound may be gently but securely united by three interrupted sutures. The first is applied to the middle of the edges on the anterior surface; the second, about opposite the first, to the posterior edges. The curved needles need not penetrate more deeply into the substance of the lobule than about one-third of its thickness.

Fig. 63.

By the third suture, the small flap (*c b*) left at the posterior part of the lobule, is made to bridge over the lower extremity of the gap. The needle, therefore, is first thrust through the free end (*c*) of the little flap, and then through the lower edge of the wound in the anterior portion of the lobule, the suture tied, and the operation is finished. No dressing is required. In three days the sutures are removed. In every case thus operated on, immediate union has been obtained by Dr. Knapp.

I have tried this method in several cases, and have found it the only means of preventing the notch so often seen in the lobule after it has healed.

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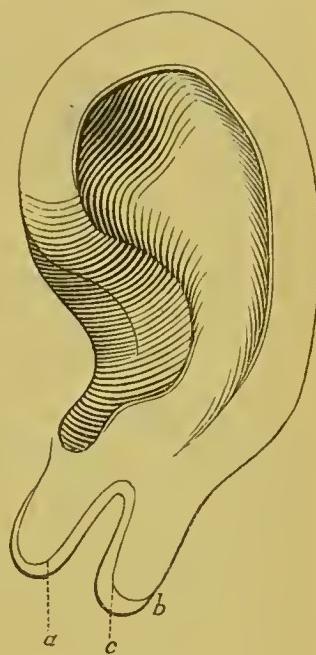
SECTION III.

EXTERNAL AUDITORY CANAL.

CHAPTER I.

CIRCUMSCRIBED AND DIFFUSE INFLAMMATION.

OTITIS EXTERNA CIRCUMSCRIPTA consists in a circumscribed inflammation of the skin or subcutaneous cellular and fibrous tissues, terminating in a small abscess or boil, which, in discharging its contents, produces considerable destruction of the skin covering it. Its seat is not confined to any particular portion of the auditory canal, but as it is most likely to occur in a region rich in glands, it is apt to be found in the outer part of the meatus. It may, however, arise in the deeper cellular tissues and in the periosteum of the bony portion of the auditory canal. Circumscribed inflammation of the external auditory canal may arise sporadically or epidemically, and, in the latter instance, it is a striking fact that the abscesses are confined to a particular part of the auditory canal.[1] Bonnafont[2] has recorded such an epidemic, occurring in Paris, in May and June, 1863, and Gruber[3] reports the occurrence of a similar endemic attack of this disease in the summer of the same year in Vienna, at which time, the majority of the abscesses were found in the outer third of the auditory canal, near the tragus.

Symptoms.—This disease is usually extremely painful, and is attended with fever and even considerable cerebral symptoms in some cases. The boils usually occur one at a time, but the series may amount to a dozen. Sometimes they appear to

[1] Gruber, Lehrbuch d. Ohrenh., p. 297.
[2] L'Union Médicale, 1863.
[3] Bericht Allg. Krankenhaus, Vienna, 1863.

merge so fast into each other, that the ease gained by the discharge of one is hardly enjoyed by the victim until the throbbing and burning pain of a new one warns him that he must endure the torment of another.   The auricle may become sensitive to touch and traction, especially if the abscesses are in the cartilaginous part of the canal, and the patient then cannot endure the ordinary pressure of the affected side of the head on the pillow.   But such sensitiveness of the ear is not so likely to occur in this form of otitis externa as in the diffuse form. The severest pain and most distressing symptoms are found when the boil is seated in the unpliable parts of the bony portion of the canal; intense distress, however, may be caused by a boil seated just within the opening of the auditory canal. Usually, the gravity of the pain and febrile symptoms will depend upon the depth of the abscess in the tissues of the auditory canal as well as upon its proximity to the drum-head.   Small superficial abscesses do occur in the meatus without any pain, a sense of discomfort and dulness of hearing having been the only cause of the patient's seeking surgical relief.   More than one such case has been seen where the abscess had run its full course and was on the point of discharging without having caused the patient any pain.   But of course such cases are rare exceptions, and are explained by the superficial seat of the inflammation.   Hardness of hearing and deafness are prominent symptoms of furuncles in the auditory canal.   In some cases the deafness is almost absolute, and the congestion being so great, and extending consecutively even into the cavity of the tympanum, the deafness is the last symptom to disappear.   But the patient can be assured of the ultimate return of the hearing in such cases if there has been no organic lesion of the drum-cavity, and as such a lesion is a very unlikely occurrence in this disease, there is every hope of the return of the hearing.

Inspection of the auditory canal and membrana tympani is usually very difficult if the disease is advanced and the swelling of the meatus considerable.   This difficulty is less likely to occur when the disease is in the cartilaginous part of the ear, for it may be gradually stretched by the speculum.   When the disease is in the bony portion of the canal, one can usually obtain a view of the drum-head only in the earlier stages of the disease.   In such cases, if the abscess is seated near the drum-

head, it will be seen that the latter is more or less congested at that point nearest the abscess, and in many cases where the boil is near the periphery of the membrana tympani in its upper half, considerable swelling will be found in the region of the membrana flaccida or the folds of the drum-head. In such cases, at first sight, one may be inclined to diagnose the disease as myringitis, but the history of the case, and the comparatively normal condition of the drum-head, excepting at the points of secondary congestion produced by the circumscribed inflammation of the canal, and the greater pain in the latter disease, will make the true diagnosis easy. When the abscess in the bony portion of the canal becomes fully developed, the view of the drum-head will be entirely cut off, and the deafness and tinnitus become great. After the discharge has occurred, the drum-head may be seen as a red, and somewhat sodden membrane, which, however, gradually, in a few days, assumes its normal color and outline, and the hearing will be found to be returning.

Inspection of the auditory canal and drum-head by means of the ear funnel, unless carefully done, becomes very painful to the patient with this disease of the ear; but it is very important to examine the canal well, in order to determine the seat, the amount, and the stage of the disease, as well as to be assured of the absence or the presence of exostoses, cerumen, or other foreign bodies in the canal, which might interfere with the escape of the products of inflammation and greatly complicate the disease. Having established the presence of either or all of these complications, one must mitigate the effects of the exostoses, and remove, if possible, any other obstructions, such as cerumen, foreign bodies, etc., by the most gentle and thorough syringing, or by the most careful manipulation.

If exostoses are in the auditory canal, care must be taken not to mistake such rounded prominences for the furuncles. This, in some cases, may prove to be no easy task, and, therefore, as these growths, if congenital, are usually in both canals; if there be any suspicion that the affected ear contains such bony growths, the well ear should be examined, and if it contains them, caution should be observed in ascribing all the swelling in the diseased ear to the furuncles. However, as these prominent growths of bone are not very frequently seen

in the ear, they will not often be found as complications in circumscribed external otitis, but it is well to bear in mind the possibility of their presence in the affected ear.

Etiology.—Perhaps no disease of the ear has so many asserted causes, yet so few well-explained ones, as boils in the external ear. No class nor condition of men appears exempt from it, and in many instances the disease continues to recur for a long time, owing to the fact that the cause, which must be removed before permanent recovery can take place, has not been found after the most thorough search. According to some authorities, a particular article of rich food has been the cause of the disease, especially in the more wealthy classes, while anæmia and poverty have most usually been considered fruitful causes of furuncles in the external ear.

Fatigue and consequent debility from any cause may produce them ; and, it is not uncommon to find furuncles in the auditory canal of young devotees to fashion after a long and gay winter season with its round of parties and fatiguing attendants of late hours, bad air, indigestible food, and loss of sleep. I have never seen this disease in little children.

Treatment.—Of course the best treatment for a boil or circumscribed abscess is a poultice or some form of heat and moisture. But this is not easily applicable to such inflammations in the auditory canal, on account of the narrowness of the passage and the necessary blocking up of the canal which such a treatment might entail. It has, therefore, been deemed best to incise, as deeply as possible, a furuncle in the auditory canal as soon as the circumscribed abscess is detected, without waiting for pus to form in it.

With the meatus lighted as well as possible by the aid of the forehead mirror, though in some cases direct light will be sufficient if the furuncle is not too far down the auditory canal, and while the head of the patient is allowed to be entirely free, the surgeon may make a thorough and deep cut into the small abscess, taking care that the patient is allowed to jump away from the operator rather than towards him, an end best gained by allowing the patient's head to be entirely unsupported, on the unaffected side, *i. e.* the side opposite to the operator.

The knife is the quickest and surest way of escape from the pain of these furuncles in the auditory canal. It has also seemed

that in those cases where the knife has been used promptly on
the first boil that makes its appearance, others are less likely to
come, or if they come, to be less severe. This may be due to
the sudden relief, given to the distended vessels of the skin of
the canal by the free cut, at the outset of the inflammation. If
the knife cannot be used, other means must be resorted to.
Although poultices, in the strict sense of the term, cannot be
applied to abscesses in the auditory canal, unless situated very
near its mouth, and even then only in a limited way, the con-
stant or oft-repeated use of warm water by gentle instillation,
the aural douche, or some of the varied forms of irrigation, will
be found very grateful to the patient and favorable to suppura-
tion. The simplest and perhaps the best way of applying warm
water as a dressing to any acute inflammation in the ear, and
especially in the auditory canal, is to fill up the ear with warm
water and allow it to remain there as long as possible, while
the patient of course lies down with the affected ear uppermost.
To the warm water thus used laudanum or morphia, preferably
the latter, may be added. Magendie's solution may be repeated
often in warm instillations (5-10 drops) to the affected ear, and
will be found very quieting and perfectly safe, even in children.

A small dossil of lint or cotton soaked in glycerine or equal
parts of glycerine and water, and small conical poultices of flax-
seed (Roosa), will be found to act as excellent emollient dressings
upon an abscess near the mouth of the auditory canal.

The local abstraction of blood with two or three leeches,
directly under the ear in the depression behind the lobule, or in
front of the tragus, close to the ear, will also give great ease
when the congestion and pain are intense. This method has
been found very grateful when the abscess is in the bony meatus
near the drum-head.

The removal of the discharge, which is often very copious, is
of great importance. Some form of alkaline wash will be found
to act best as a cleanser after the contents of the abscess are
being poured into the auditory canal.

First of all stands warm water made slightly opalescent with
castile soap, which should be applied by means of the syringe
twice or thrice daily according to the amount of discharge.

In the interval between the syringings, or just before them,

solutions of bicarbonate of soda, x–xx gr. to f℥j, and of biborate of soda, gr. x to f℥j, may be instilled into the meatus in quantities of 10–15 drops warmed. These, by remaining in contact with the affected spot, will soften any hardened crusts of the discharged matters from the abscess and facilitate their removal by the syringe. Usually the wall of the meatus becomes so tumid and macerated that syringing, no matter how thoroughly done, will not give the perfect view one could desire of the diseased spot and the parts adjacent to it. In such a case the meatus should be gently wiped out or swabbed out with a piece of cotton fastened to the cotton-holder.

This is not painful if carefully done, and will usually give the best results so far as gaining a view of the abscess and the membrana tympani beyond. By this means, too, the everted edges of the ragged abscess may be pushed down to something like a level with the wall of the auditory canal, and the drum-head may then be seen.

It has been said that syringing the ear will usually relieve the deafness caused by a circumscribed external otitis. This will hardly be so if the disease is seated near the drum-head, i. e. in the bony canal, for in such cases the congestion of the drum-head is too great to permit an immediate return to hearing by merely syringing.

As has already been said, the occurrence of a small abscess or boil in the auditory canal, denotes that there is a tendency towards the occurrence of another or several in the same spot. Hence, the constitutional, as well as the local treatment becomes of the greatest importance.

Perhaps no greater index of constitutional or blood derangement can be found in the form of furuncles, than in the occurrence of them in the auditory canal. Hence, whatever is employed for their cure, when occurring elsewhere in the body, should most surely be employed when they make their appearance in the auditory canal, for they are not only an evidence of the need of an alterative treatment, but they are intensely painful and interfere with hearing.

At the head of the list of remedies stand iron and quinine, while in some cases iodide of potassium has been found most efficacious in breaking up a tendency to the formation of boils. But there is no specific in this malady, and if one form of treat-

ment does not bring about the desired result, another must be tried, until the trouble disappears. Most frequently, the best results will be gained from those remedies which improve the general condition of the patient. Von Troeltsch strongly recommends the internal use of Fowler's solution in this disease.[1]

Local Treatment.—Although local causes have very little to do with this disease of the auditory canal, it will be found advantageous to combine a local treatment with the giving of medicine internally. The use of some soothing or mildly stimulating salve, as the case seems to demand, has been found apparently to diminish the tendency to recurrence of the abscesses and to favor an early return to healthy action on the part of the various cutaneous structures. As a soothing application, nothing is better than a little cold cream smeared on a camel's-hair pencil and then painted round the walls of the meatus.

If a more stimulating ointment is needed, the following will be found to answer very well:—

> ℞—Hydrargyri ammoniati, gr. i–ij.
> Ung. aq. rosæ, ℥j.—M.
> Ft. ung. S. apply to the ear with a camel's-hair pencil.

A small portion of this ointment may be smeared on and around the affected spot, twice or thrice daily, by means of the hair pencil, for several days, until the skin of the auditory canal appears to be free from the tendency to the formation of these small and painful abscesses. If there is no return of the abscesses, the congestion soon goes from the drum-head, and the hearing will be restored.

The granulations sometimes left by a furuncle in the ear are best treated by cauterization with solutions of nitrate of silver (gr. 10–100), applied by means of a little cotton on the holder, or by chloro-acetic acid, applied in the same way.

As the granulations are distinctly marked centres of disease, touching them is much safer than instillations applied to them.

As a rule, one may wait to see what course granulations originating from a furuncle in the ear will take. They may fall off and be washed out, or they may grow and assume a polypoid nature.

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[1] Diseases of the Ear, 2d American edition, p. 102.

If they are found to be increasing in size, they should be touched as indicated above. If they are evidently not growing larger, or are diminishing in size, there had better not be any kind of caustic applied to them. Mild astringents and cleansing with the syringe are then sufficient. A fuller consideration of the best treatment for polypoid granulations and polypi following external otitis will be found further on, where those forms of disease are specially alluded to.

Diffuse Inflammation of the External Auditory Canal. —This disease has been called, preëminently, external otitis, because it invades the entire external ear, not excepting parts of the auricle in some cases. Its only essential difference from the disease treated of in the preceding pages, otitis externa circumscripta, consists in its diffuse distribution to the entire external ear. It is not possible to say with certainty in what anatomical portion of the structure of the auditory canal it has its seat. It has indeed been wisely said that "a simple erythema of the cutis in the auditory canal may be considered the lightest form of the disease, and a periostitis of the canal may be called the severest form."[1]

Just as the circumscribed inflammation in the auditory canal shows the peculiar tendency to narrow itself down to a very minute point, the true abscess, the diffuse form of otitis externa shows the peculiarity to spread rapidly to all parts of the external ear.

A pure form of periostitis of the external auditory canal never occurs, for the disease is never confined to the periosteum, but from the outset all the neighboring layers of the wall of the canal are attacked. This is due to the fact that the skin of the canal is more firmly united to the periosteum than the periosteum is to the bone. Hence, an inflammation of the cutis readily extends to the periosteum and the bone, this being most probably the usual course of the disease. There is also a consecutive form of external otitis found in cases of acute otitis media.

Symptoms.—The subjective symptoms of diffuse external otitis are more severe in the primary than in the consecutive form.

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[1] Gruber, op. cit., pp. 3–4.

In the former instance pain, tinnitus, and deafness are the prominent and very distressing symptoms. Roosa has found that itching in the meatus is a constant but frequently disregarded symptom of the approach of this disease.

In general the subjective symptoms do not differ greatly from those of the circumscribed external otitis. In the so-called diphtheritic form the pain is said to be intense, continuing without any interruption day and night until the inflammatory product has assumed another character. (Gruber.)

The deafness in diffuse external otitis is perhaps more marked and more obstinate then in the circumscribed otitis, while the tinnitus is very annoying in both.

The consecutive variety of diffuse inflammation of the external ear is as a rule less painful than the primary variety. This feature is most marked when the inflammation of the external ear is consecutive to purulent inflammation of the middle ear.

The objective symptoms of diffuse external otitis vary with the position, cause, and grade of the inflammation, being more severe in the primary than in the consecutive form. When the inflammation is situated in the bony portion of the canal, the disease assumes the nature of a periostitis with intense and continued pain, whereas the symptoms are not so severe when the disease seems to be limited to the outer part of the auditory canal. At the beginning of the disease the skin of the auditory canal is more or less swollen and red, and, in some cases, portions of the cutaneous lining of the auditory canal may be excoriated or even exfoliated at certain points.

Usually the redness and swelling are most marked in the bony portion of the canal, with of course great narrowing of the calibre of the canal, so that the latter appears to run to a point, thus assuming a conical shape. The skin of the fundus of the canal becomes puckered by the swelling, and one, perhaps more of the ridges thus formed will shut off the drum-head from view.

The congestion and swelling will be greatest in the region of the vessels supplying the hammer and the membrana flaccida, but the entire drum-head soon loses its gray color and its contour, so that the walls of the canal and the membrana tympani cannot be distinguished from each other by their appearances, as they are fused into each other.

All traces of the normal pyramid of light are lost, and the infiltration in many cases is so great that the consequent puckering of the drum-head will cause several shining spots to appear on the prominent points thus produced by the swelling of its layers, when light is thrown into the canal from the mirror. The appearance of the disease is somewhat changed when the layers deeper than the skin of the canal are more diseased than the cutis itself.

In such cases the swelling of the structure beneath the cutis will push it so much out of place that the two sides of the canal will be made to touch each other, and not even the narrowest speculum can then be pushed between them so as to gain a view of the deeper part of the auditory canal and the drum-head. Very often in such cases, as the superficial layer of the skin of the passage is very little diseased and remains quite dry, it may be somewhat difficult to say whether the disease is diffuse or circumscribed inflammation of the canal. However, in the former case we shall usually find more or less glandular swelling and tenderness about the ear, with pain on moving the jaw. A most important symptom in some cases is the redness and swelling, with some œdema, of the mastoid process.

The glandular tenderness under and in front of the auricle is, however, a much more frequent attendant of this disease of the auditory canal, than the mastoid redness and tenderness.

The discharge of the products of inflammation in this disease may occur from several points, but usually it comes from one only. In the former instance the disease manifests symptoms similar to those of circumscribed external otitis, whereas, in the latter instance, the symptoms are peculiar to a true diffuse external otitis. In such a case, the discharge is remarkably copious, beginning as a discharge of colorless or bloody serum, and terminating in the course of a few days in a less copious purulent discharge. The amount of odorless bloody serum at the beginning of the discharge is so abundant in some cases, as to require the constant holding of a handkerchief to the ear, in order to protect the bedding or the clothing of the sufferer, and thus several handkerchiefs, in the course of the day, may be soaked with the discharge. The most marked instance of a flow of this kind the author has ever seen, was from the ear of

a Japanese naval officer, from whom the discharge was very red as well as very copious, so red, indeed, that the patient considered it blood. It continued three days, and was succeeded by a light-yellowish discharge of purulent matter, exfoliation of epidermis from the fundus of the auditory canal and drum-head, with perforation of the latter in the postero-inferior quadrant on the eleventh day. The brief mention of this case leads naturally to the statement that many cases of this disease, when situate in the bony portion of the canal, are attended with exfoliation of large pieces of epidermis and perforation of the drum-head from *without* inward. Perforation of the drum-head does occur frequently as a result of the ordinary course of the disease, but great caution in the use of the syringe should be observed at the stage of exfoliation, for fear of penetrating the drum-head by the force of the stream of water. The swelling and exfoliation of the soft parts of the canal may be so great as to increase the pain and distress of the patient by a further distention of the canal, and the renewed irritation of the diseased part may reproduce considerable fever, which, however, subsides as soon as the exfoliated matter and discharge are removed.

Where it is impossible to gain a view of the drum-head on account of the narrowing of the auditory canal, resort must be had to the catheter, the use of Politzer's bag, or Valsalva's method of inflation, in order to ascertain the condition of the Eustachian tube and middle ear. This is often of the greatest moment, not only in children in whom it is often difficult to make a perfect diagnosis in this disease, but also in adults, in order to determine whether or not the external otitis exists alone or is accompanied by deeper and more serious trouble in the drum-cavity. All the objective symptoms in diffuse inflammation of the external ear are modified by their causes and the diathesis of the patient. Hence, peculiar symptoms may be expected in that form of the disease produced by the presence of vegetable or animal parasites in the ear, in the diphtheritic form of the disease, and in any form in syphilitic or scrofulous individuals as well as in any traumatic case occurring in the more healthy, for in the latter instance the means by which the disease has been produced must be taken into

account, for almost invariably it will complicate and alter the symptoms.

The *diphtheritic* form of diffuse external otitis is not only very rare, being unmentioned by many authorities, and, according to the best observers, is never a primary affection, but rather an occurrence in the later stages of the inflammatory process. This form of the disease is usually found in scrofulous subjects in whom the original inflammation has been either neglected or improperly treated. In all such cases, after the usual purulent discharge has lasted a longer or shorter time, there is a sudden increase of pain and fever, with the simultaneous appearance of a white diphtheritic membrane, which adheres most closely to the inflamed structure, and when even lightly touched causes intense pain and some bleeding of the parts beneath, as shown by Gruber. Moos,[1] and G. A. Callan,[2] have each reported a case of idiopathic diphtheria of the external auditory canal.

In children there is often found, at the termination of an attack of diphtheria, inflammation in the external ear. This rapidly extends in some cases, directly to the bone of the canal, and backwards to the mastoid process. Pain is not a prominent symptom in these inflammations following diphtheria, and this fact will readily distinguish them from the truly diphtheritic form of external otitis in which the peculiar false membrane is found in the auditory canal. The form of the disease now referred to is one arising from the broken-down condition of the little patient, rather than a form of disease already described as the diphtheritic. In the former case the pain is not great, the swelling is considerable, and the tendency to attack the bone is marked. Fluctuation is soon felt over the mastoid region, and, after the evacuation of the pus, the bone beneath is felt denuded, and in some cases crumbling. Exuberant granulations spring up around the opening made by the knife in the soft parts, and the peculiar depressed mouth of a sinus leading to dead bone soon begins to make its appearance. With a probe, a tract of bare bone corresponding to the region around the bony meatus may be detected. For weeks, no por-

[1] Archives of Oph. and Otol., vol. i. No. 2, New York, 1870.
[2] New York Med. Record, March 27, 1875.

tions of this diseased bone will come away, but at last the nearest edge of the dead tract will appear to rise up, so that a probe may be worked under it, and then gradually, day by day, the dead shell or scale of bone (for it is in many cases the outer wall of the mastoid cells) will be found to be coming out through the sinus. This process is attended with more or less discharge from the ear, but if the sinus behind the ear is kept freely open, the discharge from the auditory canal will be very slight, and hence, granulations are not usually found in such a case, for the drainage is kept up from behind and away from the auditory meatus. During this process the patient has no pain, the discharge is not very copious, but there will be, from time to time, swelling of the glands in front of and under the ear, and down the tract of the sterno-cleido-mastoid muscle. These swellings are not painful nor very hard. They last for a few days and then usually disappear, though they may suppurate in the worst cases. Perhaps the form of inflammation over the mastoid, just sketched, may be due to the inflammation of a gland which has become diseased by the diphtheritic poison.

In badly fed and delicate children the diphtheritic form of otitis externa may pass into the *gangrenous* variety. According to Gruber, otitis gangrenosa is much more likely to occur in children than in adults. Although the external otitis occurring in diptheritic children may lead to necrosis in and about the tympanum, with exfoliation of large pieces of the posterior wall of the auditory canal, I have never seen such cases assume a truly gangrenous nature.

Causes.—The causes of diffuse otitis may be purely idiopathic or local. The latter variety will be found the most usual, as cold, wounds, injuries of all kinds, furuncles in the auditory canal, and various inflammatory processes both within and outside of the ear. The latter diseases attack the auditory canal from their nearness to it, as, for example, acute inflammation of the middle ear, some skin diseases, as eczema of the scalp and auricle, the acute exanthemata, and in rare instances pemphigus of the entire surface, may also attack the auditory canal and drum-head, as in a case seen by Von Troeltsch.

The improper uses of all kinds of ear-picks, aurilaves, hair-pins, and tooth-picks, for scratching the ear or for the too

zealous removal of cerumen, are constantly found to have been the exciting cause of this very painful disease of the auditory canal.

Some of the worst cases I have seen, especially among the patients in the infirmary, have been produced by the rough and persistent use of pins, which appear to have an especially bad influence on the glandular structures of the auditory canal.

I have also observed that men very often make a very improper use of a quill tooth-pick in scratching the meatus with it. This practice I have known to excite a series of obstinate abscesses which have at last passed into a chronic form of diffuse external otitis. This latter form of the disease is not very painful, but the itching and discharge are very annoying.

There are constantly found a few writers disposed to attribute some cases of diffuse inflammation of the external ear to syphilitic or gonorrhœal causes. The disease in the former instance is attributed to papules, the secretion from which is irritating (Gruber); and other writers, among whom is Lincke, have endeavored to diagnose some forms of external otitis as syphilitic. The gonorrhœal form appears very doubtful, from the fact that there is no mucous membrane in the external auditory canal. Dr. Ladreit de Lacharriere[1] has described and defended a form of acute syphilitic otitis which he considers purely a secondary accident, and to which he desires to call especial attention.

These cases are said to be not uncommon, but the writer referred to laments that no one but Triquet has devoted much attention to this or any forms of purely syphilitic disease of the ear.

The disease described by de Lacharriere as acute syphilitic otitis appears to possess a very distinctive type, so much so " that it may be diagnosed as specific in its nature before the patients confess that they have had any other lesions of this nature." The characteristic signs are said to be the condition of the auditory canals, the nature of the secretion, the rapid onset, and the insignificant pain. The two canals are usually attacked at the same time. Their walls are swollen, but not to the same extent as in the phlegmonous form of otitis. The skin

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[1] Annales des Maladies de l'Oreille et du Larynx, May, 1875.

is cracked and red, and the canal is so narrowed that any endeavor to introduce a speculum will cause the patient suffering.

From further description it may be gleaned that the discharge does not differ in quality, amount, nor in any respect from that of ordinary diffuse external otitis, excepting in having a *very disagreeable odor*. The premonitory symptoms are similar to those of ordinary otitis, for they consist in sensations of fulness in the ear, itching in the auditory canal, and a discharge occurring on the same day or a little later.

The same writer says respecting the differential diagnosis in this disease that " it should never be taken for a simple otitis, the pain of which is so intense, until the discharge is established; nor should it be confounded with herpetic otitis, which can always be detected by the presence of the peculiar herpetic vesicles. The affection which most nearly resembles it is eczema, in which, however, scanty secretion which does not run out will keep it from being confounded with the disease described as acute syphilitic otitis.

" The disease usually lasts about as long as an ordinary attack of otitis, disappearing without leaving any traces, excepting in some few cases in which the subsequent deafness appears quite persistent either from a thickening of the drum-head or from a catarrhal condition of the tympanic cavity."

It would seem, from this description, that this disease is a well-marked and independent one. Its symmetrical character, disagreeable odor, copious discharge, and attendant syphilitic history would certainly tend to place it among lesions secondary to the specific inoculation. When the catarrhal tendency induced by the specific poison is borne in mind, it would seem that the form of otitis just described might be consecutive to a catarrhal process in the middle ear.

Treatment.—If we are able to begin the treatment of diffuse inflammation of the external auditory canal in the early stages of congestion and pain, the course to pursue will be to apply leeches around the ear, in front of the tragus, close to it, and under the auricle close up behind the lobule. From four to six large European leeches may be applied in this manner, the exact points to which they are to be applied being indicated with ink, for the guidance of the leecher if the surgeon does not wish to, or is unaccustomed to, put them on. Some authorities are also is favor of applying a leech to the wall of

the meatus near its mouth, the meatus being previously well stopped up with cotton beyond the point the leech is to be placed. The only disadvantage of this method lies in the liability of producing an abscess at the leech-bite. But depletion, thorough and copious, must be brought about in the first stages of this disease, and if leeches will not give the desired relief, thorough and deep scarification, especially by making a deep cut on the superior wall of the meatus, should be promptly carried out. This is very much more painful than leeching, but it depletes the affected spot at once, and the bleeding may be kept up by syringing the auditory canal with very warm water.

If, notwithstanding the leeching and scarification (if the latter is resorted to, as a second choice), the swelling and pain continue, it will be necessary to apply heat and moisture. In this respect the treatment will not differ materially from that of circumscribed inflammation in the auditory canal.

Warm water should be constantly and gently applied to the affected auditory canal by irrigation or by instillation. When warm fluid applications are to be retained in the auditory canal, the best way to accomplish this is for the patient to lie down with the affected ear uppermost, as already stated when discussing the subject of furuncles in the auditory canal, and the fluids should be kept in the ear as long as they are warm and grateful to the sufferer.

To the water thus used may be added various anodynes, preferably, however, laudanum or morphia. Magendie's solution undiluted will be found to be the best anodyne application, because it is the cleanest and most powerful, and, although it should never be resorted to in the undiluted state, unless the pain is very severe, it can be endured in large quantities in the ear, without producing any unpleasant narcotism, even in young children.

It may be used in instillations of five or ten drops, every half-hour, until relief from pain is obtained, in children as young as three years of age, with the best results. I have frequently used it thus, without observing the least narcotism.

The best way to prescribe it is in small quantities, thus:—

> ℞.—Morphiæ sulphatis, gr. iv ;
> Aquæ,[1] fl℥ij.—M.
> S. Ten drops, warm, in the ear, as required.

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[1] For water, cherry-laurel water may be substituted.

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The only caution to be observed is, that the apothecary read the quantity of water correctly, for it has happened that the quantity of drachms has been read as ounces, with, of course, no worse result than weakening what would otherwise be a more powerful and more desirable application for the relief of pain. The object of the small prescription is, as will be readily seen, to prevent sixteen grains of morphia from being at the command of patients, when four grains will do just as well, with proportionately less risk.

It is, perhaps, needless to say, that all forms of solid poultices of carrots, onions, fat pork, oils, etc., will only tend to aggravate the present sufferings of the patient, and almost inevitably leave behind them portions of the poultice, which, by undergoing decay, or becoming rancid, will lay the foundation of other evils, among which will be found the aspergillus playing a prominent part.

The secretion in the diffuse inflammation of the auditory canal may be very copious, and of a sanious nature. This must be carefully removed, and the ear kept as clean as possible by frequent and gentle syringing with pure warm water, to which a little castile soap or bicarbonate of soda may be added. If the secretion should be tenacious and tend to accumulate in large quantities, and syringing fail to remove it, it should be carefully and gently wiped out with cotton on the cotton-holder.

The cotton-holder should never be used by the inexperienced or inexpert hand, as in that case it will prove itself as unworthy an instrument as an aurilave, or sponge tied to a stick, which pushes in much more than it brings out and *never* fails to do harm sooner or later.

As the copious serous discharge, often tinged with blood, diminishes, the running from the ear may assume a yellow color and become thick, but much less in amount. This will be apt to assume a chronic tendency, and the deeper parts of the canal may be found red, disposed to bleed, and roughened into little hillocks. The discharge is so much thicker that it is not easily removed, and excites a tendency towards the growth of granulations near the membrana tympani. It becomes, therefore, extremely important to cleanse the ear at this stage and keep down the granulations.

I have found that the principle of aspiration applied to the

tumid and sluggish parts will not only cleanse them but stimulate them into a healthy activity.

After cleaning the ear as thoroughly as possible, by syringing and the cotton-holder, especially in those cases where the dermoid layer of the drum-head has been greatly inflamed, thrown into hillocks, and suppurates freely at several points, I have seen through the Siglé pneumatic speculum, as I have sucked upon the India-rubber tube attached to its side, large drops of pus ooze from the openings in the dermoid layer in quantities sufficient to fill up the fundus of the auditory canal. By this means it is possible to cleanse the inflamed deeper parts much better than by any other means. It is surely the most rapid and perhaps the only immediate way of doing it when pus has accumulated under the dermoid layer of the drum-head or in deeper tissues of the skin of the canal, which enter into the structures of an abscess in the wall of this passage. Whether the abscess be of the nature which forms in circumscribed otitis, or the more diffuse and sluggish kind found at the subsidence of the diffuse form of inflammation of the auditory canal, this method of cleaning out the diseased parts may be used. At the same time that the pus escapes from the sodden parts in such a case as already alluded to, in which aspiration is employed, I have observed that minute drops of blood start out from the excoriated parts everywhere in the canal. This acts as a stimulant to these parts, which do not bleed when touched with the cotton-holder; but their bleeding upon gentle suction with the Siglé speculum reveals their true sluggish nature and will guide in the treatment.

These are the cases which demand the use of strong solutions of nitrate of silver, and we should not hesitate to apply solutions containing 60 to 100 grains of the caustic, every day or two, until the ear becomes more healthy: if neglected, granulations will soon spring up.

At home, the patient should keep the ear carefully cleansed and use a solution of zinc, copper, nitrate of lead, and other astringents. But, as a rule, the zinc, in the form of the sulphate or acetate, combined with tincture of opium, in these cases of excoriation of the canal, will be found the best remedy. The following recipe is of value:—

R.—Zinci sulphatis, gr. v ;
  Tinct. opii, ♏xx ;
  Aquæ destill. fl℥j.—M.
S.   Ten drops four times daily in the ear.

It may be well to repeat the direction, that all applications to the ear must be warmed before they are dropped into the ear.

When the disease is confined chiefly, if not entirely, to the external ear, as in diffuse inflammation of the external auditory canal, lead is frequently employed by the highest authorities.

When granulations spring up in the canal, Politzer, in his clinic, prescribes instillations of lead-water and the application of crystals of sesquichloride of iron. These crystals are applied rapidly, in order to prevent their deliquescing, and after they are placed upon the granulations the canal is packed with cotton, and the whole retained for twenty-four hours, if no discomfort and pain arise from the treatment.

By this means, granulations may be made to disappear rapidly, when they are too small and numerous to be pulled out with an instrument. Hinton[1] recommends the following formula for chronic forms of inflammation in the auditory canal:—

R.—Liq. plumbi diacetatis, ♏ x–xxx ;
  Acid. acet. dil. ♏ iij–x ;
  Liq. opii, ♏ xx ;
  Aq. destill. ad fl℥j.—M.

He further states : "I have found the same lotion useful, at first, in the excoriated and swollen condition of the meatus that often coexists with affections of the tympanum in children, especially if neglected."

In the treatment of granulations, as well as the roots or bases of polypi, after their complete extraction, nothing is equal to monochloroacetic acid. This is acetic acid in which chlorine replaces one part of oxygen. The preparation I have used for some years is made by Merck, of Darmstadt.

By applying a drop of this on the cotton-holder to the granulations every other day, or three times a week, they will rapidly disappear. The application of the acid is somewhat painful for an instant, but a syringeful of warm water will

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[1] Questions of Aural Surgery, p. 95, London, 1874.

relieve it. The advantages of this acid are its promptness, thoroughness, and cleanness. It cannot, however, be applied by any one but the surgeon. It should be applied only to the diseased spot under thorough illumination of the meatus by the forehead-mirror.

Some authorities speak in high terms of the efficacy of brushing granulations in the ear with tincture of opium.

If polypi should spring up, with well-defined base or pedicle, they must be extracted by one of the various means described further on, and their attachment to the canal thoroughly touched for several days with monochloroacetic acid. In every case where polypi are pulled out, the patient should be told before the extraction that it will be necessary to touch the base of the growth with the acid or some other caustic.

The treatment just described is that adapted to the ordinary form of otitis externa diffusa with no worse complication than polypoid granulations or polypi; there are, however, several other forms of this disease, as already stated, viz., the diphtheritic, the gangrenous, the syphilitic, and the parasitic.

The treatment will be modified in the first three, by the fact that they are much more painful than the fourth. As the first three indicate a constitutional alteration and poisoning of the blood, their treatment must be largely of a supporting and alterative nature. Their names will indicate the kind of blood-poisoning they are due to, and their general treatment must be conducted on the principles followed in the same diseases when they manifest themselves elsewhere in the body.

Otomycosis.—The growth of either a vegetable or an animal parasite in the external auditory canal, may excite in the latter a form of diffuse inflammation, to which the general term, *parasitic otitis* may be applied.

Judging from the literature of the subject and my own experience, animal parasites are found in the external auditory canal much less frequently than fungi. No special name has been suggested for that form of diffuse external otitis excited by the presence in the auditory canal of animal parasites, but for that kind of aural inflammation excited by the growth of fungi in the auditory canal, the general term otomycosis has been suggested by Virchow.

The subject of animal parasites and insects accidentally lodged in the external ear will be considered under the head of foreign bodies in the ear, but we shall consider at this point that form of diffuse external otitis produced by vegetable parasites.

The most common cause of this form of otitis externa diffusa is the growth in the auditory canal of that kind of fungus called Aspergillus. Its two chief varieties are A. nigricans and A. flavescens, the former of which is found in the ear twice as often as the latter. The ascomycete, *i. e.* the highest form of development of the Aspergillus, is, as we shall see further on, of very rare occurrence in the ear. Other kinds of fungi have been found in the auditory canal of man, viz.: the *Graphium penicilloides*, by Hassenstein and Hallier; the *Ascophora elegans*, by von Troeltsch; the *Tricothecium*, by Schwartze and Steudener; and the *Mucor mucedo seu fuscus*, by Böke.

The Aspergillus is so very much more common in its occurrence in the external ear than other fungus, that the aural inflammation it produces is named by Wreden, of St. Petersburg, *Myringomycosis aspergillina*, for he has observed that this vegetable parasite has an especial proclivity to grow upon the membrana tympani.

Myringomycosis aspergillina has been most thoroughly described by Wreden,[1] but before his works were published, Mayer[2] and Pacini,[3] Carl Cramer[4] and Schwartze, had described the occurrence of this form of parasitic disease in the external ear. Subsequent to the appearance of Wreden's papers, various authors[5] have given fully detailed accounts of this disease and its successful treatment. In seventy-four cases of the disease observed by Wreden, only two forms of fungi have been found, viz., the A. flavescens and the A. nigricans, excepting in one

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[1] Die Myringomycosis aspergillina und ihre Bedeutung für das Gehörorgan, 1868; and Myringomycosis aspergillina, 1869–1873, according to personal and foreign observations, Archives of Oph. and Otol., iv. i., 1874.

[2] Beobachtungen von Cysten, mit Fadenpilzen aus dem äusseren Gehörgange, Müller's Archiv, 1844, p. 401.

[3] Supra una muffa parasitica nel condotto auditiv esterno, Florenec, 1851.

[4] Sterigmatocytis autacustica, a variety of Aspergillus, Vierteljahrschrift d. Naturforsch. Gesellschaft zu Zurich, 1859–60.

[5] Schwartze, Von Troeltsch, Böke, Politzer, Gruber, Weber-Liel, J. Orne Green, C. J. Blake, Roosa, Bezold, Lueæ, Nölting, Bezold, et al.

solitary case, in which there was found a fungus richly supplied with capsular sporangia or asci, and which, on account of its intense purplish-red color, was called by Wreden the *Otomyces purpureus.* This fungus was examined by Woronin, a distin-

Fig. 64
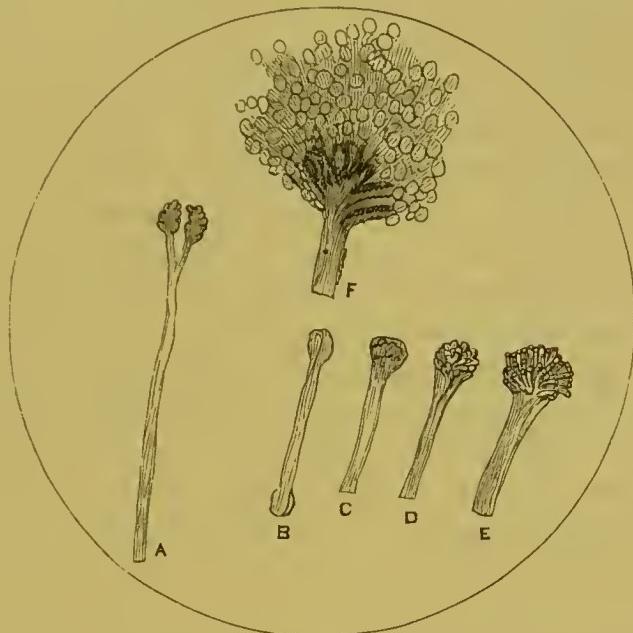
FORMS OF ASPERGILLUS FLAVESCENS REMOVED FROM THE HUMAN EAR.—A. Unique form of double-headed fruit stalk from the ear of a man. B, C, D, E, and F. Various stages of development observed in a specimen taken from the external ear of a female affected with a growth of Aspergillus in both auditory canals.

guished mycologist of St. Petersburg, who pronounced it to be essentially different from the Ascophora of Schenk, which belongs to the Mucorini. Upon further investigation, this proved to be the ascomycete or utricular form of the *Aspergillus nigricans,* the highest form of the " specific aural fungus" of Wreden. Its fertile hyphens were seen to have a double outline under the microscope, and at different places transverse septa, like the fructiferous hyphens in the varieties of Aspergillus which have already been found in the ear. The width of the broadest of them was 0.00572 mm. to 0.00715 mm. in diameter. The double-outlined wall of the fungus is of a bright yellowish-red color, 0.00143 mm. thick. The fruit end of the hyphen is composed of a comparatively very large, red, round, vesicular sporangium, which consists of a thick-walled capsule and a

number of round spores, which completely fill its cavity. The diameter of the large sporangia is 0.0572 mm. to 0.06435; that of the smaller ones is 0.02145 mm. to 0.0429 mm. The thickness of the capsule wall is 0.00143 mm. to 0.00214 mm. Dr. J. Orne Green[1] has lately published an account of finding in the ear a similar fungus, which he calls *Aspergillus rubens.*

Aspergillus is usually found growing at the fundus of the external auditory canal. It seems to seek the most secluded part of the canal, and hence is most likely to grow first upon the membrana tympani, from which it spreads outward over the entire auditory canal, forming a kind of false membrane in the shape of a glove-finger. This false membrane is composed chiefly of mycelial network, with all forms of aërial fructification of the plant, and some epithelium from the auditory canal. The pseudo-membrane thus formed has been said to have a lardaceous appearance; it also resembles a piece of wet newspaper lining the auditory canal. The sporangia are usually found on the surface of the false membrane turned towards the membrana tympani, and the wall of the auditory canal. Although the most perfect forms of growth of the fungus are usually found near the drum-membrane, I have seen specimens so flourishing at the mouth of the auditory canal, that the latter appeared to be sprinkled with bright-yellow pollen. In such a case, recently observed, the membrana tympani was not seriously implicated. Usually, however, the membrana tympani is injured by the aspergillus, but not permanently.

An auditory canal which has been the seat of inflammation is most liable to be invaded by the aspergillus. It seems that the remnants of the inflammatory disease, such as pus, dried mucus, epithelial débris or blood, form excellent soil for the growth of the parasite. It has been observed long ago, that an active discharge from the ear is unfavorable to the growth of aspergillus in the ear. Aspergillus cannot be in an auditory canal for any length of time without causing the characteristic symptoms of its presence; an exceptional case would seem to be one reported by Moos.[2] The growth of an aural fungus is usually confined to cutis of the membrana tympani, as shown

[1] Proceedings of Boston Society of Med. Sciences, 1875.
[2] Archiv f. Ohrenheilkunde, Bd. II. p. 155.

by Wreden, but, in very rare instances, the parasite may invade the fibrous layer of the drum-head, and finally take root in the cavity of the tympanum, as has been observed by Politzer[1] and others.

Symptoms.—The symptoms of this disease are a sense of fulness, slight pain, burning, itching, tinnitus aurium, and hardness of hearing. The vessels of the malleus become congested, and in a day or two the membrana tympani becomes hidden by a thick, white, false membrane. The slight serous discharge which now sets in, marks the detachment of the false membrane, and the cessation of the pain. In some cases the cutis of the auditory canal becomes deeply inflamed, but not invariably. The pain may become intense if the parasite is not removed. Males are more frequently attacked than females, according to Wreden, who has seen fifty-one of the former, and twenty-three of the latter sex, affected by fungi in the ear.

In ten cases of this disease which have come under my notice in private, only three were females. So far, this disease has never been found in very young children nor in the very aged. The oldest patient I have observed with this disease of the ear was a man 67 years old.

The following case, in which a perfect mycelial tube-cast of the auditory canal was removed by the author, will supply all the typical features of an ordinary attack of the disease, and will be seen to agree in the main with the observations of others. The patient was under treatment for so-called chronic catarrh of the middle ears, complicated by ozæna. She stated that for more than a year she had had, from time to time, sudden attacks of pain in the left ear, which lasted for a day or two with more hardness of hearing, and then suddenly ceased, with a slight watery discharge from the affected ear. The hearing then returned to its relatively normal state. When she told me this she was free from pain, and the drum-head and auditory canal were in the condition usually seen in a case of ordinary progressive hardness of hearing, with intact but opaque drum-head.

Within *ten* days from that time, she came to me, stating that she had had, two days before, an attack of the pain already described,

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[1] Wiener Med. Wochenschrift, 28, 1870.

and that there was still a little discharge from the ear. I examined the ear and found the inner portion of the osseous auditory meatus and the membrana tympani covered with a false membrane looking like wet newspaper. I instantly inferred the presence of a fungus, and removed the false membrane very easily by means of a pair of forceps. The removal of the false membrane caused no pain, nor were the parts beneath it very red and sensitive. There was a slight serous discharge from the ear, a drop of which I examined immediately upon a carefully cleansed slide under the microscope, and found that it contained no pus, but myriads of brownish-yellow spores of the *Aspergillus flavescens* and vibriones.[1]

The tube-cast into which the mycelial false membrane had been moulded, was composed chiefly of thalli, and upon its surface were free spores and tufts of aerial fructification of the *A. flavescens;* throughout the false membrane thus formed were scattered epithelial scales.

The hyphens, or fruit-stalks, were not septate, and their large, bulbous ends, from which the spores rise, were a beautiful golden-yellow color, and resembled, in their general shape and appearance, an ordinary onion-top.

In reference to the etiology of this case, it may be stated that the patient had lived for some time in a very damp house, the cellar of which was " covered with mould," but before she had come to live in that house she had never suffered from any fungus-disease in the ear, as far as she knew.

The chronic disease of the ear may have predisposed the ear to a development of fungi, such a tendency having been found in other cases of chronic aural disease by Wreden and various observers.

The hearing was impaired only from the onset of the pain until the false membrane was removed. Had I attempted to remove the false membrane during the pain, I might have found that its removal was difficult for me as well as painful to the patient. In this case, however, the cessation of pain, the easy removal of the false membrane, and the absence of redness

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[1] Pouchet (comptes rendus, 1864, p. 148) has found bacteria and vibriones in a discharge from the ear, attended with itching. Hinton, Questions of Aural Surgery, London, 1874, p. 79.

of the subjacent parts, seem to indicate that nature had already commenced a process of loosening and removal of the fungus-cast of the parts of the ear attacked by the aspergillus. It has been observed by others that an attempt to remove the false membrane in these cases is usually followed by pain, sometimes bleeding. This must be because the false membrane has been touched in a stage of the disease earlier than the one called the natural process of loosening, in which the tube-cast alluded to was removed.

All symptoms of the disease in this case disappeared under treatment which consisted chiefly in the use of instillations of absolute alcohol, several times daily, and persevered in for several weeks. The hearing, which was not normal before the formation of the false membrane, was found to have been unaltered by the disease, although the external auditory canal had passed through the various stages of the light diffuse inflammation incident to an attack of otomycosis.

A vegetable parasite, seeking the most secluded spot in the ear for its growth, is most likely to be found on the drum-head, but fungi may grow on the wall of the auditory canal and nowhere else in the external ear, as in a case of ascophora found by Von Troeltsch in a solitary patch on the wall of the external auditory canal.

Aspergillus not only spreads from the drum-head to the wall of the auditory canal and *vice versâ*, but it perforates the drum-head sometimes and finds its way into the drum-cavity, as in the case reported by Politzer.[1]

The following case is one of growth of aspergillus in the tympanic cavity: A young lady, 18 years old, applied in the autumn of 1872, to the author, for relief from a slight but constant discharge from the left ear. She stated that the discharge had never been attended by pain, that it was light colored and almost transparent. I found the external auditory canal free from disease of any kind, but the drum-head was destroyed excepting in the region of the tympanic folds; the malleus was still present.

It was impossible to find out how long the fungus had been growing in the ear, for when it was first detected by the

[1] Ueber pflanzliche Parasiten im Ohre. Wiener Med. Wochenschr., 1870, 28.

patient's bringing me a flake, dotted with blackish spots, which she had removed from her ear, there were no subjective symptoms different from those which had been connected with the case for years, according to her statements. In order to allay a little itching in the ear, the patient had thrust a hairpin *into the tympanic cavity*, through the largely perforated membrana tympani, and had pulled out the whitish scale, studded with black spots, alluded to.

The auditory canal was, and had been for months previous, free from all traces of anything of this nature or appearance, for she had been under constant treatment for the chronic discharge, which had obliged her to syringe the ear several times daily.

That this specimen was pulled from the tympanic cavity was fully proven by the patient's using a hairpin again and bringing out in my presence more fungi on similar scales, which were instantly examined under the microscope.

By the use of instillations of absolute alcohol thrice daily, and syringing the ear with warm water, all traces of the fungi and the discharge disappeared, and the ear remained free from itching and serous discharge for some weeks. Although the patient was living in affluence and perfect hygienic surroundings, the itching and discharge again returned, but all the symptoms were once more relieved by the use of alcohol-instillations in the ear with careful and thorough syringing.

This case I mention as a proof that otomycosis is not necessarily a disease of the external auditory canal, although as a rule it is. In the case just narrated, perhaps we have a very rare exception, unless it can be shown that in many cases a thin serous or sero-purulent discharge from the middle ear is kept up by the presence of fungi. Perhaps this case began as one of myringomycosis in which the fungus, after destroying the drum-head, excepting in the region of its folds, penetrated into the drum-cavity and flourished there.

Etiology.—Respecting the etiology it may be stated that dampness of the dwelling, previous disease of the ear, and the use of oleaginous remedies for different aural diseases are the most fruitful causes of this disease.

Otomycosis is said to be much more frequently met among the poor than in the richer classes of any country. My experience

is just the reverse. As the climate, and consequently the dwell-
ings, of northern continental Europe are damper than in this
country, we can account for the fact that this disease appears to
be more frequent there than here, and therefore attention has
been called most thoroughly to this form of aural disease by
writers in Germany and Russia.

Mr. Hinton, of London, has rarely found aspergillus in the
ear; but Dr. Cassells, of Glasgow, has met with it frequently
in his experience. Previous diseases of the ear, especially those
productive of exfoliation of epidermis, and those which have
left behind them collections of dried pus or any of the products
of inflammation in the auditory meatus, may induce a growth
of vegetable saprophytes.

It is now established beyond doubt, especially by the inves-
tigations of Bezold,[1] that the use of oil in the ear for pain is
one of the most fruitful causes of the growth of fungi in the
auditory canal and on the drum-head. Oils and all forms of
grease put into the ear are usually forgotten when the pain is
gone for which they were applied. They soon become rancid,
and thus favor the growth of vegetable parasites, which finally
produce all the well-marked symptoms of otomycosis.

The fact furnishes the strongest argument against the com-
mon and senseless use of sweet oil for all ear diseases. It is
entirely useless as a remedy for pain, and worthless as a solvent
for inspissated wax; for a little reflection will at once make it
apparent that oil will not dissolve the semi-oleaginous ear wax,
but that to soften and detach it we need only a slightly alkaline
wash. This is not only more efficient than oil, but cleaner and
free from the danger of encouraging the growth of fungi.

It would also be well for physicians to see that salves and
ointments, which must be prescribed sometimes for aural
maladies and applied to the auditory canal, are thoroughly
washed out at last, when all further need of their presence in
the canal has ceased.

In some instances, though a pure form of aspergillus may
invade the fundus of the auditory canal, a bastard form of
aspergillus and penicillium may spring up nearer the meatus.

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[1] Die Entstehung von Pilzbildung im Ohr. Monatschr. f. Ohrenh., Juli, 1873.

This has been observed by Hallier and Blake.[1] I have frequently observed the pure forms of aspergillus, but never any bastard variety of fungus in the ear.

Treatment.—Many high authorities in this country regard thorough and frequent syringing the ear with water as sufficient to destroy vegetable parasites. While this is indispensable, it is not entirely sufficient, and must, therefore, be aided by a more powerful parasiticide. One of the best and most soothing parasiticides is hypochlorate of lime (gr. ij–aq. fl℥j), as recommended by Wreden. Next to this, according to the same authority, Fowler's solution, used locally, is the most efficacious. Dr. J. Orne Green found in his own case, that hypochlorate of lime was more soothing than either carbolic acid or solutions of soda.

Bichloride of mercury, acetate of lead, solutions of veratria, tincture of iodine, and solutions of tannic acid have been recommended as parasiticides by various authorities. Having observed that a solution of bichloride of mercury, gr. j to fl℥j of water, excited nausea, dizziness, and vomiting, I have refrained from ever using this drug, in any way, as a local application in the ear.

Of course, a chief element in the treatment of inflammation in the external ear, caused by the growth of fungi, must be the removal of the patient from the source of the spores of the fungus. If it should appear that the spores are acquired from fungi growing in a damp dwelling, then the patient should be removed from such influences. It would also be well to see that the particular room or bedding occupied by the patient is not mouldy, and hence the source of the disease in his ear. The masses of fungus which have collected in the ear—and these may be so great as to extend from the fundus of the auditory canal to the meatus externus—should be removed as quickly as possible. The detached masses are easily extracted from the ear; the adherent ones can usually be pulled away by gentle traction, or a safer plan would be to go on with the use of the parasiticide until the layers of the fungus are spontaneously detached, when they can be syringed out.

[1] Dr. C. J. Blake; Parasitic growths in the meatus auditorius externus, Transactions American Otological Society, vol. i. p. 170, 1871.

Since, in cases of otomycosis, inflammation is usually present, nothing but the most soothing remedies should be employed. Warm water is absolutely an essential means of cure. This should be syringed into the ear, or allowed to flow in from the aural douche. After the ear is thus perfectly cleansed, instillations of alcohol and of hypochlorate of lime should be employed freely in the ear. The former may be used in its absolute state or diluted; the latter, in the strength of two grains to the ounce of water. It is recommended that the latter be used freshly mixed each time of application to the ear, on account of the chlorine and oxygen set free. So far, I have given the preference to alcohol, either alone or diluted with water. If the skin in the auditory canal is broken, alcohol may burn at first, but it has never in my experience increased the inflammation, and it always destroys the parasite.

CHAPTER II.

FOREIGN BODIES IN THE EXTERNAL EAR.

ANIMATE as well as inanimate bodies are frequently found in the external ear, where they become of great surgical importance from the annoyance, inflammation, pain, and deafness which they are very apt to produce, as well as from the fact that they may find their way into the middle ear, Eustachian tube, or even into the internal ear.

Their source may be either from within or from without. Under the first class may be placed: abnormal collections of ear-wax from the ceruminous glands; masses of horny epithelial scales, forming the so-called *Keratosis obturans* of Wreden; and collections of stiff hairs from the tragus and auditory canal; also clotted blood, inspissated aural discharges, scales of dead bone, and, in one sense, many of the new formations of the external ear. But, of these varieties of foreign bodies, only the first three should be considered here, and the remainder are discussed elsewhere.

Under the second head may be classed all animate or inanimate things small enough to have gotten into the external ear.

The manner in which they may get into the ear is extremely varied. Foreign bodies of this class are most frequently found in the ears of children, where they are placed usually in play, by the victim or its companions; or foreign substances may be thrust into the ears of adults and of children, by accidental or intentional violence. Animate bodies fly or crawl into the ear of man.

<div style="text-align:center">FOREIGN BODIES ORIGINATING IN THE EAR.</div>

Collections of Cerumen in the Ear.—According to Pétrequin, the cerumen consists mainly of fat and combinations of potash and fatty acids in the following proportions: In 100 parts of cerumen are found: 10 parts of water, 26 of fat, 38 of soapy combination of potash soluble in alcohol, 14 of a similar combination insoluble in alcohol, and 12 of entirely insoluble organic matter, with traces of chalk and soda.

The name cerumen is probably a corruption of a word compounded of cera and aurium, the wax of the ear. The word cerumen, however, does not appear in modern Latin dictionaries.

The appearances of an impacted plug of cerumen in the external auditory canal are not very varied. Usually, they are easily recognized, but now and then, especially when the impacted mass is due to slow accretion by the daily pushing in and smoothing down of its layers by the towel or fingers of the patient, it will not be easy for the unpractised eye to recognize the mass at once as one of cerumen; for, in some cases, the impaction has so completely adapted itself to the fundus of the meatus and the drum-head, as to resemble a dark and polished membrana tympani. In many cases such a polished mass of cerumen may be regarded as a somewhat abnormally colored drum-head, and treated as such, the deafness dependent upon the impaction of the wax being attributed to other causes, and in some way connected with the "discolored membrana tympani." Such failures in diagnosis lead to curious results.

It is, indeed, not uncommon to find patients suffering from impaction of cerumen in the auditory canal, being treated for some other aural affection which they do not possess. Thus, the Eustachian catheter and instillation of nitrate of silver have

been applied to relieve the deafness which a proper syringing would have speedily cured.

The mere fact that the drum-head is hidden from sight should be sufficient proof that an abnormal obstruction has occurred in the auditory canal, and this alone ought to be considered as the probable cause of the unpleasant symptoms for which the patient seeks relief. These unfortunate failures in diagnosis are but the natural result of the unwillingness on the part of most medical men to devote any time to the study of diseases of the ear, but they are mistakes which might be prevented if the general medical eye were at all familiar with even the appearances of a normal drum-head and meatus. In fact, many an ear might be saved if the physician first consulted could frankly state to the patient the nature and locality of his aural disease, although he might be unwilling to assume the treatment of it.

The rapidity with which masses of cerumen accumulate in the external auditory meatus varies greatly. In some individuals, I have removed second and third obstructive plugs in the course of a few months. In other cases, judging from statements of the patients, the plug must have been accumulating, and giving some annoyance in the way of tinnitus and deafness, for years. As a rule, the deafness caused by a plug of cerumen in the auditory canal is of sudden approach, although the foundation of the offending mass may be much anterior to the hardness of hearing. In most cases the aggravated deafness comes on suddenly after a bath. In such cases, the patient thinks that water has gotten into his ear and is still there, or just after washing out the concha or meatus in the morning, a little more forcibly than usual, the patient finds that he cannot hear so well. In the former case, the mass which has, up to the time of the bath, permitted the sound waves to pass it, becomes swollen by the water which has gotten into the ear, thus cutting off all approach to the drum-head. In the latter case, not only the water, but the patient's finger, by pushing the plug further in, has contributed to the onset of the hardness of hearing.

Etiology of Rapid Formation of Cerumen.—There are many opinions respecting the cause of a rapid and abnormal secretion of cerumen, such as is seen in all walks of life. As the ceru-

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minous glands are really perspiratory glands modified, it is reasonable to suppose that a large amount of cerumen is in some way connected with the perspiration. Large amounts of cerumen are found in the laboring classes, whose perspiratory system is of course very active, and I have observed that in persons leading a life of ease, in whom large and rapid masses of car-wax are sometimes formed, the perspiratory glands in the axilla are unusually active. But I am not prepared to say that when-ever the axillary glands are unusually active we are sure to find large amounts of car-wax in such cases. After certain acute processes in the ear, as for example furunculi in the canal, or an otitis media acuta, which has healed rapidly, I have ob-served a tendency to a rapid formation of normal wax in the ear. This is apparently due to the stimulation of the circula-tion of the meatus consequent upon the acute inflammatory aural disease.

It is held by some[1] that quinine, which affects the nervous structures of the inner ear, may also have great influence over the sound-conducting parts of the ear, i. e. the external and middle ears, and that therefore the secretion of cerumen is stimulated by this drug. The amount of cerumen is sometimes increased, after a tonic course of treatment for the general health, in certain cases of deafness. But the repeated formation of obstructive masses of cerumen in the auditory canal appears to be an idiosyncrasy in some cases, and is probably unexplained yet. The only apparent connection between it and other glan-dular activity has already been mentioned as possibly occurring in some cases in which active perspiratory glands and abnormal accumulations of wax have seemed to be united. But in such cases great care must be taken to discriminate between impac-tion of cerumen and keratosis obturans, a disease to be described hereafter.

When the onset of hardness of hearing in cases of impacted cerumen is rapid, it will usually be found that the mass has formed without the knowledge of the patient, and is in no way due to his endeavors at cleansing the auditory canal.

When the deafness due to impacted cerumen has been coming on slowly for months, sometimes for years, it will usually be

r Roosa ; Transactions American Otological Society, 1872.

found that the patient has been in the very bad habit of swabbing out his ears, most commonly with the rolled-up corner of a towel, and sometimes with that most pernicious and reprehensible implement, a piece of sponge fastened to a stick, and sold by the druggists under the high-sounding name of an "aurilave." In these cases the plug will be found well packed in and moulded to the fundus of the auditory canal and drumhead.

Such masses are not very hard to remove, considering the long period of their accumulation; they are usually found to contain large quantities of short fibres of cotton or linen from the towel used in the efforts to cleanse the ear.

Impaction of cerumen by attempts at cleansing the meatus not only occurs among adults, but is found among children, whose over-anxious attendants are constantly swabbing out the meatus of their charges, with a corner of a towel, or with other means.[1]

Such cases may sometimes result in what may be called a chronic ulcer of the bony portion of the auditory canal, or in the growth of a large polypus from an ulcerated spot on the wall of the bony meatus very near the drum-head.

In these cases of artificially impacted epidermis and cerumen, the foreign mass usually assumes the form of a hollow cast of the auditory canal, or a glove-finger, with a cast of the drum-head on the tip. These cases are usually stubborn, and in some instances threaten the integrity of the bony structure of the auditory canal.

In a case which I saw recently, not only a polypus sprang from the ulcer in the auditory canal, but the drum-head was ulcerated through, and water passed into the pharynx when syringed into the external ear.

The patient, a boy eight years old, was carefully watched over by his nurse, who used daily the so-called aurilave, upon the little patient's ears. The impacted mass of epidermis and cerumen at last excited pain in the ear, and upon removal of the mass, which came out in the glove-finger shape, the skin of the auditory canal was found to have assumed almost the appear-

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[1] Similar conditions of the ear have been observed by Mr. Hinton of London. See supplement to Toynbee on the Ear, London, 1868, p. 429.

ance of a mucous membrane. The most ulcerated portion was at the anterior wall near the drum-head, and the latter was perforated largely at the postero-inferior quadrant. The discharge was rather thick and dark-colored, not very copious, somewhat offensive, but the hearing was very little altered.

Under daily syringing and mild astringents the membrana tympani closed up, and the patient disappeared from my treatment for six weeks, at the end of which time, when he was brought again to me, the membrana tympani was found to be still intact, but from the ulcerated spot in the canal near the drum-head, a polypus, the size of a small pea, was detected in the furrow between the drum-head and the antero-inferior part of the bony canal. The polypus was removed, the discharge ceased directly, and the hearing became normal.

Treatment.—The treatment of simple impaction of wax in the ear consists in the use of the syringe, as explained already (p. 175).

Cretaceous Bodies in the External Auditory Canal.—
According to Rau[1] cretaceous masses in the auditory canal are the rarest kind of foreign bodies found in the ear. But accounts of such bodies being scattered throughout the works of other writers, they appear not to have been very uncommon. Du Verney and Leschevin[2] appear to have had frequent examples of them in their experience, and in Williams' Treatise on the Ear[3] (London 1840), the statement is found, on the authority of Autenrieth of Tubingen, that " in the bodies of almost all old people there is found, in the innermost part of the meatus auditorius externus, a firmly attached lump of indurated ear-wax, which, in old age, acquires a disposition to crystallize, partly in an earthy form," and also that " Morgagni has found the cerumen of the hardness of stony matter." But these bodies are not frequently met in the present day. I am

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[1] Ohrenheilkunde, pp. 367–368. The authorities given are, Thom. Bartholini, acta medica et philosoph. Hafniensia ann. 1671 et 1672, 4 T. I. p. 82. L. C. F. Germanni, de miraculis mortuorum libri tres. Dresd. et Lips , 1709, 4 Lib. 3. Tit. 3. Sect. 50, p. 1090. Du Verney, p. 156. C. J. Myller, miscell. nat. cur., Dec. 2, Ann. 6, Obs. 262, p. 326. Collomb, Œuvres Méd. Chirurg., Paris, 1790, p. 304.

[2] Lincke's Sammlung, I. No. 1, p. 29, 1835.   [3] p. 184.

not aware of any record of such a case in modern literature, nor have I ever met such cases in the many hundreds of ears of old people I have examined in various infirmaries. But, since it is a well-known fact that mineral substances, such as potash, chalk, and soda, enter into the composition of the cerumen, it is not improbable that now and then stone-like bodies are found in the auditory canal, which owe their existence to the mineral elements of the cerumen. If they were once more frequently met with than in the present day, and such appears to be the case, it can be accounted for only by the greater prevalence of the custom of syringing and cleansing the ear among the laity at the present time.

Treatment.—If such bodies should be found in the ear, the treatment of them may be effected as detailed in the general summary at the end of this chapter.

Laminated Epithelial Plug in the External Auditory Canal.—This obstructive disease of the external ear has recently been described by Wreden[1] of St. Petersburg, and named by him keratosis obturans, in contradistinction to ceruminosis obturans, the impacted plug of ear-wax, with which it has often been confounded, though differing from it very widely. The latter disease, as its name implies, consists of a mass of inspissated cerumen, but it is easily removed by proper syringing, and the ceruminous nature of the mass removed from the ear is recognized, among other features, by the rapidity with which it dissolves in water.

Keratosis obturans, however, recently described as a separate and special disease of the ear, is a collection of epithelial laminæ, derived from the cutis of the external auditory canal, of gradual accretion, causing great deafness, and very obstinate in its resistance to removal. Every one who has had any extended experience in removing from the ear impacted endogenous masses, usually of cerumen, must have noticed that now and then a peculiar mass is encountered, requiring a *piecemeal* removal by patient, and careful use of syringe and forceps, and which, after lying a long time in water, will not dissolve as ordinary ear-wax does. It is such exceptional masses that

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[1] Archives of Oph. and Otol., 1874.

Wreden has investigated, and, finding that their composition is not of cerumen but of the horny elements of the cutis, he has proposed for them the name of keratosis obturans.

These obstructive bodies are not confined to any age or sex. Wreden states that his attention was first called to their peculiar nature by meeting a very adherent one in the ear of a little girl. In this case he was so fully impressed with the suspicion that he was dealing with a wad of soft white paper, maliciously placed in the ear by the young patient, that he accused her of the deed, and, although she denied it, he was not convinced of the truth of her denial until the microscope revealed the fact that the mass he had with great difficulty removed was composed of epithelial elements arranged in peculiar laminæ. Upon inspection of an ear containing such a mass as has been described, a thin layer of ordinary cerumen may be seen covering the outer surface of the plug, and hence the impression often gained that the case is one of ordinary ceruminous impaction. But continued syringing, by its barren results, soon convinces the operator that he has encountered no ordinary obstruction.

The first case of this disease I had the opportunity of observing occurred in July, 1874, since which time I have seen several cases in private as well as in the infirmary. The patient was a banker, sixty years old, suffering from sudden and intense deafness in the occluded ear, with some tinnitus and vertigo. The auditory canal was almost entirely blocked up by the dense, horny mass, with the outer end covered by cerumen. The patient stated that ten years previous he had been liable to attacks of pain in the auricle, especially about the lobe, which were followed by a crop of vesicles and pustules, probably a form of herpes zoster. Since then he has had no pain in or about the ear, but at times he has noticed, without any apparent previous cause, a thin and somewhat offensive discharge. At first sight I thought the case one of impacted cerumen, mingled possibly with inspissated mucus and pus, but the utter failure of the attempts with the syringe to move the impacted mass at the first sitting convinced me that the case was one of those described as keratosis obturans.

Owing to the fact that the auditory meatus was rendered abnormally tortuous by two large exostoses of the canal, one above, the other below, it required patient and careful picking

and syringing for half an hour for eight days before all of the foreign body was removed, with, at last, a restitution to normal hearing. From statements of the patient it appeared probable that similar though smaller and less annoying plugs had been removed from the same ear before, by himself, but he could not give any idea as to the length of time the present one had been forming, as the onset of deafness, the only symptom first attracting his attention to the ear, had been almost instantaneous. This patient had a slight return of the disease, one year after the above attack, but it was entirely removed by soaking the mass repeatedly for twenty-four hours with a solution of bicarbonate of soda (gr. xx) in glycerine and water, āā f℥ss.

Usually in these cases of keratosis in the external ear, no part of the mass comes away as a coherent plug, but the whole must be broken down and removed in small pieces. In the case narrated, however, about half of the mass was removed as a well-defined plug.

When the horny and laminated mass was first washed out of the ear, it was perfectly white, and resembled a set of layers of wet tissue-paper slightly separated from each other by the buoyant effect of the water. When pressed upon, it had the tough leathery feel of a wad of wet paper, which peculiarity will always distinguish it from the ordinary cerumen-plug of soft and greasy consistence.

As insolubility of the removed mass is one of the distinctive features of this peculiar aural disease, a mass may remain as long as five months in glycerine and water without undergoing change. I exhibited such a mass at the Philadelphia Pathological Society, in December, 1874. This specimen, for several months longer, lay in the same preservative fluid, and still there was no dissolution of the mass. Of course, had the mass been formed of ceruminous elements, it would have melted down almost instantly, and distributed itself throughout the fluid.

This resistance to solution will readily account for the difficulty of its removal from the ear.

Etiology.—No cause has been suggested for the occurrence of this disease of the external ear, and, although among the laminæ composing these masses Wreden has sometimes found vegetable spores, he is not inclined to ascribe the origin of the mass to the irritative presence of a fungus in the auditory canal.

I have observed that the walls of the auditory canal in these cases is not healthy, but presents a more or less roughened surface, with inflamed hillocks, and it may be a chronic inflammation of the skin of the canal, which predisposes it to this peculiar and slow exuviation of its horny elements, which being retained in the canal, at last form into this extremely tough and resisting plug.

Treatment.—In cases showing a decided tendency to recurrence or renewal of these growths in the ear, care in preventing an accumulation of the horny laminæ, by close watching and speedy removal of the slightest amount of scales, will greatly simplify the disease and the treatment.

The solution of soda already mentioned (p. 295) will be the simplest and the best loosener of the plug from the wall of the canal, but sooner or later recourse must be had to forceps and blunt probes, for this disease seems to furnish the exception to the rule never to use anything more forcible than the stream from the syringe for the removal of foreign bodies from the ear. Of course the greatest care must be observed in the use of such instruments, and no one but the most experienced surgeon is justified in attempting to remove such a mass by instrumental means.

It is with great caution that I advise their use, and still greater caution that I use them ; but as I have resorted to them, and only by their use succeeded in removing the keratosis, I must, in these cases, give their due to such instruments. With perfect illumination of the meatus, proper instruments and cautious movements, added to a thorough knowledge of the use of the implements and the part to be operated on, success must attend their application.

The forceps, represented in the wood-cut, same size as original, is made to open and close very gently, and, being slender, cannot take a very firm hold upon the impacted mass of keratosis, but it is strong enough to pick off and lift away portions of the obstruction. The loss in strength caused by the narrowness of the branches of the instrument is fully compensated in the greater illumination gained by its slender shape, and it is also a much safer instrument than the stronger, thicker, and stiffer forceps usually made for removing foreign bodies from the ear. For removing objects more delicate than masses of

keratosis obturans, it is of the greatest value. It is just as necessary to have such a delicate instrument as this to lift things from the ear, as it is to work with delicate and very pliable forceps in manipulating small objects undergoing preparation for microscopic use. In fact most aural instruments are too large. Illumination of the canal has too often been sacrificed to the strength of the instrument.

Fig. 65.
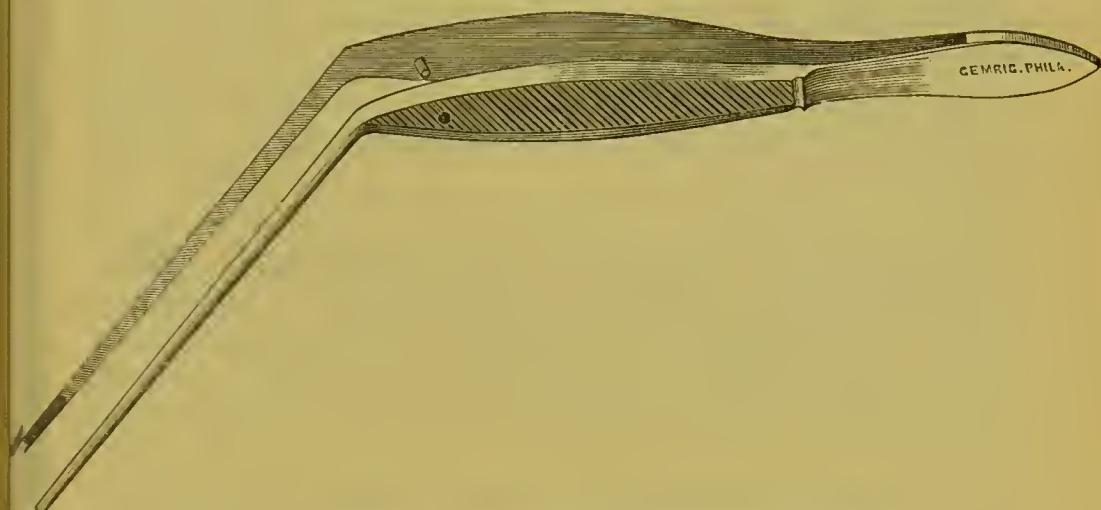
DELICATE FORCEPS FOR REMOVAL OF FOREIGN BODIES FROM THE EAR.

Prof. Gruber[1] recommends forceps with branches quite as delicate as these, but much shorter. The longer branches enable the operator to keep his hand much more easily out of his own light.

I fully agree with those who earnestly deprecate the use of any other instrument than a syringe for the removal of foreign bodies from the ear, as we shall usually find that where a syringe will not remove the foreign body no other instrument will serve our purpose. But like all other good rules, it has its exception.

The forceps of course must never be tried until all other means have proved of no avail, and then only in the hands of the most experienced and under the most perfect illumination ; for any manipulation of the ear resembling a blind grappling after the foreign body will most surely prove disastrous. Un-

[1] Lehrbuch d. Ohrenheilkunde.

fortunately the proper occasion for the use of the forceps is almost invariably in an emergency, and is performed by the most unexperienced hands. An examination into the facts of the case, moreover, where they must be used, will usually reveal that originally they were not needed, and the simplest syringing at the outset would have rendered the use of any other instrument unnecessary.

The only justifiable use of forceps at the outset may be in a case of keratosis obturans, but even in such cases all instruments must be used with the greatest caution in conjunction with repeated and thorough syringing. The accidents happening to the ear, from the ignorant use of instruments for the removal of foreign bodies, are very numerous and are increasing in number all the time.

Ingrowing Hairs from the Tragus, resting on the Membrana Tympani.—Sometimes, though rarely, the growth of hair on the tragus may be so copious as to block up the external meatus or pass into the canal and rest upon the drum-head. Such cases have been observed and reported by Dr. Weir,[1] of New York.

In some instances the entire auricle, especially at the helix and tragus, may be the seat of excessive and almost ludicrous pubescence. In such cases of excessive amounts of hair near the auditory canal, loose hairs may get into the auditory passage, or masses of them block it up so as to induce hardness of hearing.

The symptom of single hairs on the drum-head will be a scraping sound heard only by the patient whenever the jaws are moved. If cerumen aid in the matting of the hair about the external meatus, considerable deafness may be the result.

Treatment.—Epilation may be applied to the hairs on the tragus as a preventive means. If the hairs have led to obstruction in the canal, the foreign mass must be removed on general principles.

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[1] Transactions American Otological Society, 1870, p. 30.

FOREIGN BODIES FROM WITHOUT.

Inanimate Objects.—From time immemorial children have pretended to place various kinds of seeds, beads, etc., in one ear and bring them out at the other, for the amusement of themselves or their younger and more ignorant companions. The latter are often victimized by attempting to imitate the deeds of the elder children, and succeed only as far as inserting the foreign body. Some time ago, I removed a honey-locust bean from the ear of a negro-boy, thirteen years old, where there is every reason to believe the bean had been introduced two years before. The bean was in a perfect state of preservation, and had given no trouble to the boy, who said he had been induced to " put it in his ear, because he had seen the big boys do the same thing, pretending to remove it again through their noses." He had tried the experiment and failed, but, as the inserted bean never gave him any pain, he had never told any one of it, "for fear of parental punishment." While examining the ear for purposes of comparison with another, I discovered the bean, whereupon the boy told the above tale. The bean was finally lifted out by forceps with the greatest ease.

Children are very fond of stroking their faces and various parts of their body with beads or any similar object with a polished surface. It is while thus amusing themselves, by stroking their ears, that beads, etc., often slip into the auditory canal. The variety of such bodies found in the ear is endless, being wads of paper, all kinds of seeds, and small beans, beads, round tips of pencils and penholders, pieces of slate-pencils, and little stones, buttons, etc. Usually the foreign body is placed in the ear by the victim; sometimes it is pushed in there slily by his playmates. Sometimes during quarrels various long objects, such as straws, pencils, pen-holders, bodkins, etc., are thrust into the ear maliciously, both among children and adults.

I remember a case in which a woman, having a grudge against a man, watched her chance to box his ear, during the time he scratched his ear with a pen-holder, such being his custom. The opportunity offered itself, the man received his box on the ear, and the pen-holder, being pushed suddenly into the canal, penetrated the drum-head.

While this could hardly be called a foreign body which

remained in the ear any length of time, it serves to show how the ear may be injured by even a short presence of a foreign body in it. Foreign bodies remaining some time in the ear are usually found among little children, as already stated, or if a foreign body is found in an adult, it will often be found upon inquiry to have been put there during childhood.

I have in my cabinet a specimen illustrative of such a case. It is a blue bead seven mm. in diameter, four mm. in thickness, and perforated at its centre, removed with a mass of inspissated cerumen from the right meatus auditorius externus of a woman 68 years old.

The patient was entirely unaware of its presence in her ear, and, of course, could give no account of its mode of getting there. It was in all probability placed there in her childhood and forgotten, as it produced neither pain nor deafness. Later, however, the accumulation of cerumen became so great as to cause deafness, and the removal of the obstructive mass to relieve the deafness led to the discovery of the blue bead.

Upon closer inspection of the bead by the patient, she stated that she could recall having played with just such beads when she was about eight years old, and such being the case, it is fair to presume that the bead had quietly rested in her ear for sixty years, one of the longest periods of retention of a foreign body in the ear on record.

Dr. Ludwig Mayer,[1] in an article on foreign bodies in the ear, mentions four cases in which the foreign substances were in for four years, two for twenty years, one for forty-five, and one for over sixty years.

The case I have just narrated would of course be a rival of the last one named in Mayer's list.

Deleau states that he once removed a small snail-shell from the auditory canal of a woman, who knew nothing of its presence in her ear.[2]

The same author relates having removed from the ear of a boy five years old another shell (pucellage), after it had caused pain and distress by its presence in the ear for a year.

Marchal[3] extracted a coral bead, with a ragged surface, from

[1] Monatsschr. f. Ohrenheilkunde, Jahr. IV. No. 1.
[2] Gazette Médicale de Paris, tome ii. 1834, No. 11, pp. 161–163.
[3] Revue Méd. Française et Etrangère, Jan. 1844.

the ear of a military officer fifty years old, in whose ear the bead was placed when the patient was fifteen years old.

Some time since I removed by a few gentle streams from the syringe a small pearl shirt-button from the ear of a little girl six years old, after I had given her ether. Before she came to me her ear had been very roughly handled by picks and probes, but not *once* syringed. As she had become very nervous about the painful treatment of the ear, I gave her ether, and the ease with which I syringed out the button only served as another proof of the folly of instrumental picking, probing, pulling, etc., to remove a foreign body from the ear. The ear had commenced to discharge when I first saw her, and the canal was greatly swollen, yet the syringing brought away the offending body. Yet we hardly dare call such a body offending; that term should be applied to the heroic treatment with curettes, etc., to which the unfortunate little victim had been subjected.

All kinds of corrosive and scalding fluids, melted metals, etc., are not only exceedingly painful but threaten the life of the sufferer if poured into the ear. Morrison[1] records a case of death following the instillation of nitric acid into the ear. Rau[2] states that melted lead poured into the ear of a drunken man produced deafness with purulent discharge and paralysis of the corresponding half of the face, and became so firmly imbedded in the ear that as late as seventeen months after this accident the metal could not be removed. A case similar to that reported by Rau recently occurred in St. Mary's Hospital, Phila., during the service of Dr. Schell.

Within a short time I have seen the evil effects of scalding fluids upon the ear. The case was that of an Irish girl, 20 years old, who had been induced to pour *boiling* oil into her ear for some slight trouble in it. The agony which ensued was intense, and, although the acute symptoms had ceased entirely when I saw her, the drum-head was white and thick, like a piece of heavy paper, and the hearing was gone.

It would seem almost superfluous to mention such folly, but the general ignorance respecting the delicacy of the ear demands such recitals as warnings.

[1] Wilde, page 378.
[2] Ohrenheilkunde, § 319, and Med. Chirurg. Zeitung, 1872, No. 39.

While considering fluids which have proved highly injurious to the ear, it may be well to consider briefly some of the odd and, in a measure, irritating fluids placed in the ear for the cure of otorrhœa, deafness, etc. As these fluids have usually done no harm, beyond causing a loss of time and money to the patients, the recital of them may afford another proof of the general ignorance of the nature of ear diseases, and a universal tendency towards doing the improper thing for this delicate organ.

Among a large number of patients from the ignorant classes frequenting the dispensaries and infirmaries in our city, I have rarely met one, whose malady was of any duration, who had not tried applications of human urine, woman's and cow's milk, cow-dung, rabbit's fat, neats-foot oil, Harlem oil, the juice of clams and oysters, eagle's gall, etc.

Only one man, forty years old, mentioned the imaginary excellence of eagle's gall, but he had spent considerable time and money for more than a year in his endeavors to obtain this coveted cure, and, at last having succeeded in getting it, he had applied it for a long time to his ears. As the man had brought on, by his life of a hunter, an obstinate and progressive form of middle-ear catarrh, it is needless for me to state that his disappointment was great at the want of success on the part of his long-sought remedy for deafness.

A curious and self-inflicted irritation from a foreign body in the ear occurred in the case of a young printer, finally applying for relief at the author's clinic in the Philadelphia Dispensary in 1872. The young man stated that two weeks previous to his call at the dispensary, he had placed the core of a roasted onion in his ear, for a slight earache. The pain soon ceased and the onion core was forgotten or " supposed to be absorbed" by the patient, until the secondary irritation, discharge, and hardness of hearing caused by its presence in the auditory canal, drew the patient's attention a second time to his ear. Without any further attempt at self-medication, he applied at the dispensary for relief, and, upon examination, I found the auditory canal entirely blocked up by the swollen and rotten remains of the onion core. The walls of the canal were irritated and excoriated, and a horribly stinking discharge poured from the ear, while the mechanical deafness was great. One good syringe-

ful of warm water removed the offending mass, restored the hearing, and revealed the fact that the drum-head, though deeply macerated, was still intact. With the use of an astringent wash for a few days, this man regained a sound ear.

Sometimes the foreign matter is entirely harmless of itself, and might remain in the ear indefinitely, without exerting an injurious effect. The efforts at its removal, made by the ignorant, are the true cause of injury to the ear. This is illustrated in the following case:—

On the 30th of April, 1872, Mr. E. S., a machinist, 39 years old, consulted me for pain and deafness in the left ear. He stated that three days previous, while crossing a street, a horse had splashed mud in his ear, which at that time was perfectly sound. Upon returning to the shop where he was employed, his ear was examined by some of his comrades, who said they saw "something in the ear," and proceeded to extract the foreign matter with "*chips and mechanics' small tools.*" This of course caused the patient great suffering, for he said "*several little white* pebbles were taken out" (probably ossicles, as there was no trace of them in the ear when I examined him), and great deafness ensued in the thus roughly handled organ. The pain increased, and a large, red, hard tumefaction appeared under the left auricle and extended to the angle of the inferior maxilla. The patient, naturally a very strong and powerfully built man, was very pale, anxious, and bathed in cold sweat when I made the first examination. There was no discharge from the ear at the time he presented himself to me. My large testing watch, audible at least forty feet, was heard by this man only about two and one-half inches. He heard my voice only when I spoke very close to his ear, and this probably, only by bone conduction. The tuning-fork, vibrating on the vertex, was heard by the patient very distinctly in the affected ear. Upon inspection I found the meatus in this case uninjured. A small piece of black street-mud was adherent to the antero-superior quadrant of the periphery of the membrana tympani. The membrana tympani was found to have been entirely destroyed, excepting a very narrow peripheral band, and there was not a trace of an ossicle visible, all of these important structures having, without doubt, been torn out by the ignorant endeavors of the man's friends to remove the mud which had been splashed

into the ear. The inner wall of the tympanic cavity was fully
exposed to view, revealing healthy, pale, shining mucous mem-
brane, slightly abraded on the promontory. By the Valsalvan
method of inflation air passed through the perforation with the
characteristic whistle.

Twenty days later I saw the patient again at the dispensary.
He had been hard at work ever since the injury, not excepting
Sundays. He had entirely neglected to follow any of the simple
directions I had given him, viz., to apply three large leeches to
the swollen glands near the auricle, and to remain quiet. The
pain and tumefaction had disappeared, however, and the patient
was ruddy and cheerful once more. No air passed through the
perforated drum-head at this visit, and the hearing distance
remained permanently unaltered. Upon inspection I found the
edges of the perforated membrane adherent to the promontory
and inner wall of the tympanum, the former appearing to pro-
ject into the meatus in consequence of the excessive retraction
of the small remnant of the membrana tympani around it.

It is interesting to notice the sudden and great loss of hearing
in this case, as showing the comparatively greater importance
of the destroyed ossicles than of the perforation and destruction
of the drum-head. A simple accidental perforation of the mem-
brana tympani or drum-head, rarely, if ever, causes such a degree
of deafness as was found in this case, in which the evulsion of the
ossicles must be regarded as the real cause of the great deafness.

The impaction and long retention of foreign bodies in the
ears of children may lead to deaf-dumbness, which may be
cured by removal of the obstructions in the external auditory
canals, as was shown in a case observed by Dr. Sara E. Brown[1]
of Boston. In this case, twenty-eight small gravel stones which
had lain in the external auditory canals for seven years were re-
moved, and recovery of the hearing ensued. This child, a lad of
sixteen years, was an inmate of a school for feeble-minded chil-
dren, where he had been placed in consequence of his retarded
mental development, following his deafness. After the pebbles
were removed, the lad became more intelligent in expression, and
he regained the use of his speech, which he had begun to lose at
the age of nine years, when he placed the gravel stones in his ears.

[1] Archives of Oph. and Otol., vol. iii. pp. 88-90, 1874.

Animate Objects in the Ear.—Usually, insects which are found in the ear have crawled or flown in during the sleeping hours of the patient. Of course this is most likely to happen to those who sleep upon floors or on the ground. Bakers, who, working at night and becoming very tired, lie down on the floor of the bakery, always infested with roaches, are very apt to be awakened by the presence of a roach in the ear. The peculiar elongated shape of this insect permits it to wedge itself in the auditory canal, which holds it tightly enough to prevent its escape but not to kill it. It therefore is apt to make most violent endeavors with its front feet to escape, and in so doing it scratches and scrapes upon the deeper parts of the auditory canal and drum-head. Such movements are productive of great annoyance and pain to the patient, and if the animal is not removed, severe inflammation will be set up. Fleas, too, often find their way into the ear, and by their powerful leaps against the drum-head, which produce a noise said by the patients to resemble thunder, cause intense discomfort to the sufferer.

Very recently, Dr. Gassner[1] found the *Dermanyssus avium*, or chicken-louse, in large numbers, in the ear of a cow, where the parasite had excited a well-marked otitis externa. Von Troeltsch, to whom this specimen was sent, after consulting the literature pertaining to the natural and pathological history of such parasites, makes the following statement: "This animal, the *Dermanyssus avium*, has never been found in the ear of man; it would be worth while, however, to look for it in the pus escaping from the ear, as well as the water used for syringing certain diseased ears." Chicken-lice might fall into the external ear of man from chickens flying suddenly and swiftly above his head.

I examined, in the early part of the summer of 1875, an intelligent man's ear, and found large cicatrices in the membrana tympani, with greatly diminished hearing. The patient stated that in his boyhood, while playing in the fields, the so-called devil's darning needle or dragon-fly had thrust itself, or its long pencil-like body, apparently accidentally, into his ear. Instantly, great inflammation and pain were set up in the organ,

[1] Von Troeltsch, zur Lehre von den thierischen Parasiten am Menschen, Archiv f. Ohrenheilk., vol. ix. p. 193.

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and the hearing power was ultimately nearly lost. It seemed probable, from the statement made by the young man, that a portion of the insect's body must have broken off and remained in his ear, but it cannot be said positively that such was the case.

M. Guérin reported to the Société de Chirurgie the case of a soldier, who had returned from Mexico, suffering from facial neuralgia and other affections, which were relieved upon the escape of an *Ixodes hominis* from the sufferer's ear.[1]

I syringed, not long since, from the ear of a little boy two years old, a dead fly, which was totally enveloped in a kind of epithelial cyst. The mother of the little patient informed me that a year previous, in the summer time, the child had been attacked suddenly with pain, as she supposed, in the ear, and that his sufferings were so intense as to produce convulsions.

The meatus was entirely occluded by the encysted fly; but upon removal of the foreign mass, the membrana tympani was revealed as perfect, and the hearing became normal.

Dead flies are sometimes syringed from the ears of children afflicted with otorrhœa, to which they are attracted by the odor of the discharge, but in most instances produce no pain or sub-sequent trouble by their presence in the ear. I washed three from the ear of a little girl not very long ago—one the first day I saw her, in very warm weather, and two more on the following day. But there was no subsequent irritation caused by their having flown into the ear and died there.

In some instances, however, maggots grow in the ear after it has been invaded by flies. Heine[2] and Blake[3] have published accounts of the growth of maggots in the ear, and the latter authority has described minutely the apparatus by which these creatures maintain a hold in, and wound the canal and drum-head. The former writer describes a case of a little girl two years old, subject of a chronic otorrhœa, who had gone to sleep in the hot sunlight with the diseased and offensive ear exposed to the incursion of the flies, and in consequence thereof maggots had sprung up in the ear.

[1] Hinton, op. cit., p. 78.   [2] Lincke's Sammlung, ii. p. 181.
[3] Living Larvæ in the Human Ear.   Archives of Oph. and Otol., vol. ii. No. 2.

In the course of a few days, fat, white maggots, with heads spotted black, were seen in the fundus of the auditory canal. Oil was poured into the ear, and as each maggot came to the surface of the oily bath, it was seized with forceps, and thus all trouble was removed from the ear.

Heine states that he has never failed to remove maggots and all living creatures from the ear, by means of oil in a very few minutes. But the majority of surgeons have not been so fortunate.

One of the earliest if not the first case of transformation of the maggot through various stages to the fly, after its removal from the ear, is recorded by Dr. Kuntzmann,[1] who said, although he had frequently seen and read of maggots in the ear, he was not aware that any surgeon had brought about the perfect transformation of such creatures when found in the ear. The case he reports is that of a boy six years old, the son of a poor woman, who was brought to him on 17th July, 1811, for a terrific pain in the ear, which had already lasted fourteen days without any cessation. Bloody pus was found exuding from the auditory canal, which was greatly swollen. Otherwise the boy was healthy. Twenty-four hours after the boy was first seen, quantities of living bodies were detected in the ear, and six large, fully-developed maggots were extracted with the *forceps*. The pain then ceased, and all symptoms disappeared in a few days with syringing and mild astringents, and the hearing remained perfectly normal.

Each maggot was seven lines long and one line thick; their color was whitish-yellow; they consisted of several soft rings which fitted one within the other; *on their heads they had* two brown, horny hooks, curved downward, between which was the so-called dart (Réaumur), which was not exactly like that of the common house-fly maggot, but curved, yet not so much as the two hooks. This was the only distinctive feature between the two varieties of larvæ.

Two of these maggots were obtained by the author quoted, and placed in a confectioner's glass jar, in which dry and carefully sieved earth with a piece of meat was placed to furnish

[1] Hufeland's Journal der practischen Medicin, August, 1824, S. 108–111. Lincke's Sammlung, ii. p. 178.

food for the worms. They did not attack the food, but instantly buried themselves in the earth and on the second day were found to have passed into the chrysalis state.

"The chrysalides were brown, cylindrical, tapering each way to a blunt end, immovable, and consisted of several rings, like all chrysalides of the fly."

On the fourteenth day after their transformation into the chrysalis, fully developed flies escaped from the shells, which were described as "very beautiful, gray and black flies, with silver-gray head and beautiful, bright, cinnabar-red eyes; the bright redness of the eye was lost after death, and the color then became dark-brown." These flies were then presented to Count Von Hofmannsegg, who placed them in his cabinet, where they proved to be unique specimens, theretofore undescribed. Prof. Illger pronounced them to be a new species of the class *Tachina*, and named them *Tachina signata*.

To the *Tachina signata* found in this case may be added the larvæ of the *Muscida sarcophaga* (Blake and Gruber) and the *Muscida lucilia* (Blake). The pain excited by the presence of larvæ in the ear is intense, and drives the sufferer to frenzy and even into convulsions.

They are usually found in ears previously affected with a more or less offensive otorrhœa, though in the case related by Dr. Kuntzmann the ear attacked by the larvæ was entirely healthy before invaded by the fly which deposited the noxious egg. The pain attending the presence of maggots in the ear is easily explained by the investigations of Kuntzmann and Blake.[1]

The latter authority placed the larvæ in a glass vessel containing a piece of raw meat soaked in warm water, and then observed the movements and actions of the larvæ under the microscope. He found that the apparatus by which the maggot makes and retains his hold is composed of a delicate horny framework, armed with two hooks, of a stout horny nature, articulating with the aforesaid framework. By a repeated extension and retraction of the hooks, the animal pierces and tears the softest and deepest tissues it can lay hold upon. Hence it is

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[1] Archives of Oph. and Otol., ii. No. 2.

found always in the fundus of the auditory canal and sometimes in the tympanic cavity.

Treatment.—From the investigations of Blake and others it appears, that, since maggots retain such firm hold upon the structures of the ear, after they once get in there, syringing and instillations of fluids which would not injure the ear are insufficient to kill and dislodge such creatures. Blake, Gruber, and others are of the opinion that nothing short of actually seizing the maggots with suitable forceps, and pulling them out, will satisfactorily remove them from the ear.

As will be seen from the cases of Heine, Kuntzmann, and others, already recited, worms or maggots may be smothered by oil while in the auditory canal, or they may be syringed out, or they may even crawl out voluntarily, but these are exceptional cases.

Sometimes maggots do not appear willing to seize flesh when placed in their way, but burrow immediately in the earth, as already stated in Kuntzmann's case, and I have observed that a mass of maggots which were just extruded from a fly showed no tendency to seize some meat which was given them, but, on the contrary, burrowed between it and the sides of a glass vessel containing it and them.

As maggots are extremely hard to kill by any fluid not injurious to the ear, I obtained some for experiment, from a fly, by causing her to extrude her brood of 50 to 60 living creatures about 2 mm. long. These I placed in a glass vessel with the dead fly and nothing more, and after twenty-four hours found them still alive. I then placed a little piece of cold roast-beef, softened in water, into the glass for the maggots to live upon.

In twenty-four hours later I found them active and grown to be 5 mm. long, and their alimentary canals stained by the brown juice of the roast meat. In order to try the effects of some easily obtained fluids innocuous to the ear, upon the maggots, I placed a maggot, No. 1, in a few drops of refined kerosene oil. It crawled repeatedly from the oil and continued to live, though constantly thrust back and kept submerged in the oil. This maggot was finally killed in another way.

Maggot No. 2 I placed in a saturated solution of salicylic acid (bleached, prepared by Hance Bros. & White, of Philadelphia). This one died in a half hour.

No. 3 I placed in alcohol, and it died in five to ten minutes.

No. 4 I placed in ether fortior (Squibb), and killed it by this means in two minutes.

No. 5, 6, and 7 I placed in chloroform, and they were instantly killed.

Dr. Roosa has found chloroform vapor, as well as Labarraque's solution of chlorinated soda, fatal to the life of these creatures.[1]

An eighth specimen I placed in hydrant water, which seems, as Dr. Roosa has also observed, to make them more lively at first, and they continue to live and work their savage hooks for a long time, even in a glass vessel where they can gain no hold. Water appears not to have the slightest effect in arresting their work when they have once gained a hold in the soft, moist tissues of the ear. Even after they have been killed by various applications to the ear, the forceps may be required to detach them, so firm is their hold.

Calomel sprinkled over them has been said to kill maggots in the ear; also solutions of tannin have effected their destruction.

Foreign Bodies in the Eustachian Tube and Middle Ear.—In Mayer's article[2] on foreign bodies in the organ of hearing, we learn that three were found in the Eustachian tube.

One of these bodies, a barley-corn,[3] was found imbedded in the bony portion of the tube, but projected as far as the faucial end. The other two were lying in the wide faucial end of the Eustachian tube.

The imbedded barley-corn was found at a post mortem, the cause of death not given. Bougies not uncommonly break and leave portions behind them in the Eustachian tube. When the bougies are armed with cotton, feathers,[4] hairs, etc., this is more likely to occur.

In two cases, recited by Mayer, laminaria bougies broke off, and remnants were left in the Eustachian tube.

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[1] Treatise on Diseases of the Ear, p. 166.
[2] Monatsschrift f. Ohrenheilkunde, Jahrg. IV. No. 1.
[3] Prof. Fleischmann's Case. Hufeland's and Ossan's Journal, June, 1835, pp. 25–28.
[4] Hecksher of Hamburg. Mayer's Article, loc. cit.

In some instances the foreign body is rudely pushed at last, by endeavors at its extraction, into the middle ear. One of the most interesting of such cases is given by Deleau,[1] Jr.

It is that of a little boy, who placed a small gravel-stone in his ear, in play with his comrades. The unskilful endeavors with a curette to remove the body, in conjunction with the struggles of the boy, ruptured the drum-head, pushed the gravel-stone into the tympanic cavity, produced hemorrhage and inflammation of the ear, temporary paralysis of the corresponding side of the face, and excessive photophobia in the eye of the paralyzed side.

This much happened while the boy was still in the provincial town where the accident occurred. He was brought to Paris, two weeks later, and Deleau examined the ear carefully, found the pebble seated in the cavity of the tympanum, with its only visible facet in the same plane with the drum-head. By gently touching the body it was found firmly grasped by the swollen mucous membrane of the middle ear, and being so near the chain of bones all traction upon the pebble was deemed highly improper.

Deleau now wished to use forceps composed of several branches, but the patient positively refused to permit any further manipulation of the ear from without, but consented to the introduction of a firmly fitting catheter into the Eustachian tube. The third injection of water through this instrument threw the offending pebble into the concha. The otitis in this case soon disappeared, but there is no positive statement as to the condition of the hearing.

Among the rare instances of this occurrence, is one observed by Moos.[2] Before Prof. Moos saw the case, an unsuccessful endeavor had been made by a physician to remove a coffee bean from the external auditory canal, under chloroform. After unskilful manipulation the bean disappeared from view. Purulent inflammation set in, perforation of the drum-head occurred, the incus exfoliated, and numerous polypi were developed. The latter were removed, and, by syringing, together with antiphlogistic treatment and the use of astringents in the ear, the bean

[1] Lincke's Sammlung, i. pp. 153–157. Gazette Méd. de Paris, 2d Series, tome ii. 1834, No. 11, pp. 161–163.
[2] Archives of Oph. and Otol., vol. iii. pp. 103-107, 1873.

came into view, though it had passed into the tympanum and could not be seen by Prof. Moos at the first examination, immediately after the removal of the polypoid growths.

Upon the authority of Itard and Andry, Rau mentions a case in which an ascaris wandered from the alimentary canal, through the pharynx, into the Eustachian tube.

Sudden and powerful coughing in hæmoptysis may force blood through the Eustachian tube into the tympanic cavity, where irritation and pain may be set up in consequence of the foreign matter thus brought in contact with the tympanic mucous membrane.[1]

Treatment; Removal of Foreign Bodies from the Ear.—When a foreign body is said to be in the ear, the surgeon should first satisfy himself that such is really the case before he begins any operation for its removal. Grave errors have occurred from the neglect of the surgeon to assure himself on this point. When it is fully decided that the statement of the patient or his friends is really correct, that a foreign substance is really lodged in the ear, if the latter has not become irritated and swollen by the attempts of others at the removal of the foreign substance, usually a gentle syringing, the patient's head being inclined towards the affected side, that gravity may aid our efforts, will bring away the foreign body. In order to carry this out in very young children, already alarmed by the accidental entrance of the foreign body, we may have to resort to etherizing the patient. In any case, when syringing will not remove the foreign substance and the ear is at all inflamed and swollen, nothing more forcible than syringing should be attempted until the local irritation in the ear is allayed. Too often the attempts at removal of a foreign body from the ear are far more injurious than its presence in the ear.

After all irritation is allayed, which can often be effected, though the foreign body is still in the ear, syringing may be resorted to, and usually with success, in removing the foreign substance. If this fails, and it appears that other means are demanded for the removal of the impacted foreign body, the greatest care and skill are now needed, in order to avoid

[1] Eindringen von Blut, in die Pankenhöhle bei Hæmoptoë. Archiv f. Ohrenh., Bb. xi. p. 21. Dr. Küppe.

injuring the ear. A great many plans for removal of foreign bodies impacted in the ear have been suggested.

Voltolini[1] recommends the use of the galvano-caustic for the removal of foreign bodies which, by unskilful manipulation, have been forced from the meatus into the tympanic cavity and have become imbedded there. By this means, he has cut up and removed piecemeal a bean which had been pushed through the membrana tympani and pressed into the drum-cavity. A bean cannot be properly cut up, however, until it has been softened by repeated injections of water. Then momentary glowings of the finest silver wire cautery will char the bean, and the offending body can be gradually removed after several repetitions of the operation, on different days. But no one not extraordinarily familiar with diseases of the ear, as well as with the use of the galvano-cautery, should attempt such an operation. Voltolini has very justly said the most that can be asked of the general practitioner is not that he shall remove a foreign body such as this from the ear, but that he shall recognize its presence and leave it alone. It cannot be too often brought to mind that it is not the presence of a foreign body that causes ultimate harm to the patient, but the unskilful endeavors to get it out.

Among the various ways of removing impacted bodies from the external ear should be mentioned the agglutinative method. It has been recently revived by Dr. Löwenberg,[2] of Paris. This method was fully described by Riverius[3] and Celsus,[4] and is also given by Rau.[5] It consists in smearing with glue or some equally tenacious substance, a piece of linen, cotton cloth, or the like, firmly attached to a handle, which is brought into contact with the foreign body in the ear, and then allowed to remain until perfect adhesion takes place. Then, in most instances, the foreign substance can be lifted out with the above-named instrument. This method was employed in this country, some years ago, by a layman, Mr. Eli Whitney Blake,[6]

[1] Ueber fremde Körper in der Paukenhöhle und deren Entfernung. M. f. O., No. 5, 1876.
[2] Berliner Klin. Wochenschr., No. 9–10, 1872.
[3] Opera Med. Francofurti, M.DC.LXXIV., Cap de Surditate, p. 261.
[4] Strasbourg edition, 1806, p. 342.   [5] Op. cit., p. 375.
[6] C. Hooker, Boston Journal, 1834.

of Conn., for the purpose of removing a foreign body from the ear of a boy employed in his carriage factory. A somewhat similar method is to apply to the foreign body a piece of adhesive plaster fastened to a string, and then warm the minia-ture disk by means of a burning glass. When adhesion has taken place, traction on the string may remove the foreign body attached to the adhesive plaster. This method is one suggested by Dr. E. H. Clarke, of Boston.

Removal of foreign bodies from the ear by incision through the bony meatus from without and behind the auricle was proposed by Paul of Ægina, but entirely rejected by Fabricius of Aquapen-dente.[1] Recently, in the case of an impacted bone pencil-head in the tympanic cavity, Dr. Israel[2] separated the auricle from its posterior attachment to the mastoid portion of the osseous auditory canal, and, after a crescentic incision had freed the periosteum, the latter with the auricle was drawn forcibly forward, and the foreign body seized and removed through the opening thus formed. Before Dr. Israel saw this case, unskilful manipulation had driven the foreign body from the external auditory canal into the tympanum. The case then began to manifest very curious nervous phenomena. After the more acute inflammatory symptoms consequent upon the introduc-tion of the foreign body and the endeavors at its extraction had subsided, the patient complained of great pain in both arms, the trunk, and the hips, while the head and ear were free from suffering. Left pupil dilated; fibrillar twitchings in the orbi-cularis of the left eye and the left levator alæ nasi. Excessive hyperalgesia of the skin in the painful parts of the body caused the patient to scream when touched.

On the left side all the symptoms were more pronounced than on the right side. A day later vomiting and irregular pulse; contraction of the left hand forced the fingers upon the palm; the latter was overcome only by painful and forcible extension. Subcutaneous injections of atropia $\frac{1}{3}$ mgrm. relieved the con-traction, the hyperalgesia, pain, and inequality of the pupils. The hyperalgesia returned, however, and toothache set in. After the removal of the foreign body from the tympanum, all nervous phenomena vanished.

[1] Leschevin ; Lincke's Sammlung, i. No. 1, p. 25.
[2] Berlin Klin. Wochenschr. No. 15, 1876 ; also M. f. O. No. 7, 1876.

CHAPTER III.

RESULTS OF INFLAMMATION AND INJURY.

ABSCESSES in the external auditory canal may lead to an evacuation of their contents through the duct of Steno,[1] or through the cleft found in the posterior superior part of cartilage of the auditory canal as described by Poorten, after the occurrence of otitis externa circumscripta.[2]

Caries of the meatus may follow inflammation of the middle ear;[3] in such a case described by Blake a portion of the mastoid wall of the osseous meatus, one inch long and half an inch wide, came away.

Mr. Toynbee met with a case of chronic inflammation of the external auditory canal which extended to the bone and brain, producing death.[4] But these are not the commonest results of inflammation in the auditory canal. Those more likely to be met are now about to be described.

Chronic Circumscribed Ulceration in the External Auditory Canal.—Chronic diffuse inflammation of the external auditory canal sometimes ends in the formation of distinct and circumscribed ulceration at one spot in the passage.

From this diseased point an inflammatory process may be communicated to the tympanic cavity, and hence ulceration in the external auditory canal becomes of importance. Ulceration on the wall of a patulous auditory canal must not be confounded with those cases of secondary inflammation of the skin of the canal, mentioned by Kramer,[5] " which result from caries of the meatus and of the tympanic cavity, or from destruction of the membrana tympani with disorganization of the investing mem-

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[1] Hribar; Wiener Med. Presse, No. 161, 1871.
[2] Monatsschr. f. Ohrenheilk., June, 1872.
[3] C. J. Blake, Trans. Am. Otol. Soc., 1872.
[4] Diseases of the Ear, 1868, p. 73.
[5] Diseases of the Ear : Sydenham Soc., London, 1863.

brane of the tympanum. In such instances the meatus tumefies, becomes indurated like cartilage, smooth, and dark red; the opening closes up till it will only admit the head of a pin; there is a thin acrid discharge, and on introducing a probe, bare, rough, and carious bone may be felt in the deeper part." The ulcers especially alluded to here are found in the unyielding skin of the bony portion of the auditory canal, and by their general features of chronicity and sluggishness remind one of the ordinary leg ulcer. They throw off a scanty, dark-gray or greenish discharge, somewhat offensive, which shows a tendency to form a dark crust around the mouth of the canal.

Sometimes the discharge seems to have ceased, but in a few days it returns again, and, if allowed to run on, the disease will tend to form polypi and to attack the drum-head. The latter becomes congested, all its normal features are lost, and upon syringing the ear, water may pass into the nose and throat. The hearing up to this time may not be much impaired, for the middle ear has remained intact. Upon the occurrence of the perforation, however, the hearing is endangered.

In any case, therefore, where there is found a discharge from the ear with an intact membrana tympani, the most careful search should be made for the cause, and, if an ulcer is found in the bony portion of the external auditory canal, to it the treatment should be directed.

Itard,[1] when speaking of erysipelatous diseases of the external ear consequent upon erysipelas of the head, alludes to vesicles which form in the auditory canal, and upon breaking, are converted into true ulcers, which suppurate for a long time.

Others, including N. R. Smith,[2] Williams,[3] Wilde,[4] Rau,[5] Toynbee,[6] and Roosa,[7] allude with more or less distinctness to an ulceration of the meatus, as a separate and chronic form of aural disease.

Etiology.—The causes of this disease are often obscure. But

[1] Maladies de l'Oreille, Paris, 1821, p. 168.
[2] Supplement to translation of Saissy on the Ear, Baltimore, 1829, p. 218.
[3] Treatise on the Ear, London, 1840, p. 116.
[4] Aural Surgery, American edition, Phila., 1853, p. 199.
[5] Lehrbuch d. Ohrenheilkunde, Berlin, 1856, p. 179.
[6] Diseases of the Ear, 1868, pp. 79–80.
[7] Treatise on Diseases of the Ear, 1873, p. 144.

it will generally be found that a neglected inflammation in the canal has run at last into the chronic disease here described.

Treatment.—The treatment should consist in removal of any irritant which keeps up the ulcer, and in stimulation of the inflamed spot. The latter is best accomplished by cauterization by means of strong solutions of nitrate of silver or of chloro-acetic acid, conveyed to the ulcer by means of cotton on the cotton holder. All discharges are to be most carefully cleaned out by syringing, and the general health of the patient examined into and built up if necessary. As scrofulous children are liable to be the subjects of this kind of local trouble in the ear, iron and cod-liver oil will play a most important part in the treatment of such ulcerations, when occurring in them. In the interval between the applications of the above local remedies, which of course are to be effected by the surgeon two or three times a week at the outset, the patient's ear should be cleansed at home several times a day, and a mild astringent wash applied by instillation to the auditory canal. The hearing is not usually affected in the early stages, but it will be, unless the disease is arrested. The prognosis is favorable if the ear is attended to in time.

Cholesteatomatous Tumors in the Auditory Canal.—Cholesteatomatous or pearly tumors are said, by Lucæ and others, to occur frequently in the external ear. They do not appear to be common in this country. Dr. Kipp[1] has given an account of the occurrence of this disease in both ears of a man 27 years old. These cholesteatomatous masses are usually found in ears which have been the seat of chronic suppuration, but in which the latter process has apparently run its course. In such cases, the mucous membrane of the middle ear, as well as the cutaneous lining of the external auditory canal, seems to retain a tendency to the exfoliation of large masses of epithelial scales, which, accumulating in the ear, undergo a fatty degeneration and give rise to various symptoms, among which the more prominent are pain at times in the ear (but this is not a prominent characteristic of these formations), nausea and dizziness, with occasional vomiting. The hearing is of course impaired

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[1] Archives of Oph. and Otol., vol. iv.

by the mechanical hindrance offered by these masses, which may be so large as to cause absorption of the bone of the auditory canal and a consequent widening of this passage. Even greater irritation than this may ensue as a consequence of the presence of such collections in the ear, and the bone structures on which they press may become carious. The soft tissues thus pressed upon ulcerate and become covered with granulations in some instances, and the membrana tympani and ossicles undergoing erosion, the entire tympanic cavity is occupied by the cholesteatomatous layers. The microscope reveals these formations to be lamellated in structure, the layers of which are composed chiefly of flattened epithelial cells and crystals of cholestearine. In addition to these elements Dr. Kipp has found, in these cholesteatomatous masses, "fatty acids, and minute shining bodies, some round and others irregular."[1]

Treatment.—The treatment of such accumulations should consist first in the complete removal of the obstructive mass. This may require some patience, for the removal of the more external layers often reveals the presence of deeper and fresher ones, and in some cases new ones seem to form during the treatment. The latter tendency is best combated by an alterative astringent, as solutions of nitrate of silver, sulphate of copper, and zinc. The softening and removal of these masses is hastened by the use of solutions of bicarbonate of soda in glycerine and water.

Exostoses of the Auditory Canal.—Exostoses, or bony growths of a rounded, hillock-like shape, are frequently found in the external auditory canal. They are covered by the skin of the canal, are entirely painless, and the only annoyance they give is due to their encroachment upon the calibre of the canal. Their size varies from that of a merely distinguishable elevation on the wall of the canal to that large enough to occlude the canal and produce deafness. The skin covering them is a little paler than that of the canal.

Etiology.—These osseous growths may be congenital, or they may be the result of chronic inflammatory processes in the

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[1] See Dr. Mathewson's Report on the Progress of Otology, Transactions of American Otological Society, 1875.

middle and external ear. They are frequently found in those who have been afflicted for a long time with discharges from the ear, though they are also very often found in those whose ears are otherwise normal.

According to some authorities, exostoses of the meatus in some instances are plainly of a syphilitic origin. They may develop in the auditory canal at the same time with exostoses on other bones, as shown by Gruber, but he does not consider that all such bony growths in the canal have a specific origin. Contrary to the rule in other parts of the body, they are usually painless in the auditory canal. He has described several cases in which hyperplastic growths of the bone of the meatus were associated with a similar affection in the bony portion of the Eustachian tube, without, however, possessing any syphilitic origin.[1] Usually, the causes of exostoses in the auditory canal are obscure, although in many cases Toynbee's theory, that they are due to the rheumatic and gouty diatheses, may be satisfactory. As far as my experience goes, they have been met more frequently in such diatheses than in any others.

Dr. C. T. Blake[2] has described a peculiarity observed by Prof. Wyman first in the crania of Hawaiian Islanders, and subsequently in the crania of Peruvians, consisting of exostoses of the external auditory meatus occurring uniformly on the superior and inferior lips of the lamina forming the posterior wall of the passage, the same peculiar growth being described by Welker as occurring in the crania of American Indians. Out of three hundred and thirty-four Peruvian crania examined by Prof. Wyman, these growths were found in six, and in various degrees, from a small pedunculated growth on the superior lip of the lamina to double growths on both lips nearly occluding the orifice of the passage. It was noticeable, moreover, that these growths were nearly uniform in size and shape on both sides. Out of eight Peruvian crania, belonging to the collection of Mr. Blake, in the Warren Museum, but one presented this peculiarity, and then only in the form of an elongated ridge upon the posterior wall of the meatus on one side. The supposition that aquatic habits might have to do with the presence

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[1] Lehrbuch der Ohrenheilk., p. 412 and 576.
[2] Report on Progress of Otology, 1874.

of these growths, though applicable in the case of the Hawaiian Islanders, would not apply to the Peruvians, living as they did in a tract of country remote from the sea and remarkable for its aridity. That the occurrence of these growths is coincident with the development of the wall of the osseous meatus, as suggested by Dr. J. O. Green, is further supported by the fact that the location of the growths was a constant one.

The treatment of exostoses in the external auditory canal will be referred to further on.

Osseous Closure of the Auditory Canal.—The consideration of exostoses in the auditory canal leads naturally to the consideration of osseous closure of the canal and the deafness which ensues. Such a closure of the auditory canal may be congenital or acquired. In a case of the former kind, described by Knapp,[1] the closure of the auditory canal, on one side only, was associated with rudimentary development of the auricle. The acquired form appears to be the commoner, and this fact should lead to a most careful treatment in those diseases of the ear attended with ulceration and granulations in the external auditory canal. If such growths are found in the auditory canal, great care on the part of the patient should be observed in not picking at or irritating them in any way.

Acquired bony closure of the canal has been observed and described by Bonnafont,[2] Dr. L. B.,[3] Mathewson,[4] and others. In the cases named, operations for relief of the deafness were performed successfully.

The only case of bony occlusion of the auditory canal which has come under my notice presented itself in the right ear of a man 58 years old, and from the history of the case it may be called one of acquired bony occlusion of the auditory canal. At eight years of age the patient was operated on in the Pennsylvania Hospital, for polypus of the left ear. After repeated attempts at extraction of the polypoid growth, which were followed by severe cauterization with solid sulphate of copper,

[1] Transactions American Otological Society, 1870, pp. 86–87.
[2] L'Union Médicale, May, 1868; also Gazette des Hôpitaux, No. 64, 1867.
[3] Archiv f. Ohrenheilkunde, Bd. x. p. 110.
[4] Report of 1st Congress of International Otological Society, New York, Sept. 1876.

great pain and total loss of hearing, he was removed by his parents from all further treatment. In 1874, about fifty years after the above-named operations, an examination of the ear revealed a shallow meatus, closed at the bottom by ordinary skin. Nothing resembling a drum-head was visible. The skin at the fundus of the shallow auditory canal moved under the Siglé pneumatic speculum. The hearing was reduced to nothing for external sounds, per aërem. Bone conduction, however, very good on the occluded side. Tuning-fork on the vertex heard best in the occluded ear. Eustachian tube was found to be pervious to air by Politzer's method, and the ordinary catheter. The patient, a man of more than ordinary intelligence, was fully conscious of the entrance of air into his right tympanum, by artificial inflation, as well as whenever he swallowed.

As he was desirous of having an operation on the occluded ear for relief of his deafness, I made an exploratory incision with a paracentesis knife, but found that beneath the skin of the fundus of the canal, there was a bony partition cutting off the external from the middle ear. Considering the age of the patient and the good condition of his left ear, I was unwilling to perforate the bony septum in the auditory canal; but it is probable that such an operation might have been carried out with success in this case.

The pathology of this case most probably consisted in acute inflammation, followed by suppuration, which was allowed to become chronic. Then there ensued a growth of polypi, for the extraction of which, several rough and painful operations were undertaken. Subsequently, the excessive granulation-tissue became organized into a bony septum, covered by a reflection of the normal cutis of the auditory canal.

In Dr. A. H. Buck's valuable contribution to the "ultimate forms of granulation-tissue in the ear,"[1] it is stated that "a mass of granulations may become covered with skin or mucous membrane, and its central portions undergo a change into true *osseous* tissue."

Respecting this form, Dr. Buck says "it would be difficult, particularly in this locality, to determine whether a real transition from granulation-tissue to bone takes place, or whether

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[1] Transactions of American Otological Society, 1874.

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simply the *local* irritation assumes a new phase, the cellular hyperplasia or formation of granulation-tissue ceasing and bone being formed." I am of the opinion that the closure of the canal I have just narrated was caused by a transformation of a mass of granulations into true bony tissue, at a point about half-way down the auditory canal. Since the subcutaneous and submucous tissues of the ear are, at the same time, periosteal coverings, it is reasonable to suppose that such acquired osseous occlusion as has been described cannot be so very rare, but often escapes recognition.

Treatment.—Exostoses in the external auditory canal demand no treatment, unless they occlude the canal and cause deafness by this obstruction. Then they may be bored through or cut away, as has been suggested and performed by several operators.

Dr. Mathewson, in the case referred to, p. 320, used successfully the dental lathe as the motive power to turn the drill. The skin is to be removed in these cases before the bone is operated on, and to do this, Dr. Mathewson has employed the instrument known among dentists as the sealer. The bony growth was then perforated at several points near its centre, with the smallest of the drills, about one and a half mm. in diameter. This was easily done, and then larger drills, two and a half to three mm. in diameter, were used to widen the opening thus gained in the bony diaphragm. The hemorrhage was not excessive, though there was enough to slightly interfere with the operation. But the auditory canal was kept syringed and swabbed out, so that in half an hour a complete canal to the drum-head was made. The granulations which arose subsequently were combated with nitrate of silver, and in the course of a few weeks the drum-head could be seen at the fundus of the canal. The discharge gradually ceased, and the hearing became normal.

As Dr. L. B., of Hamburg, gives an account of an exostosis in his own auditory canal, and the operation on it, by Dr. Knorre, of the same city, the case demands more than a passing notice:

The first symptom of deafness occurred in the patient's forty-third year, in 1868, after a bath. On attempting to pick the ear, to free it from water which was supposed to have lodged there, an obstruction was felt by the patient, which he seized and roughly pulled upon. This caused considerable pain and

inflammation, with diminution of hearing. Upon consulting
Dr. Knorre, the obstruction was pronounced by him an exostosis
near the membrana tympani. Mild astringent treatment was
advised to allay the discharge and inflammation excited by the
patient ; the hearing then gradually grew better, and four years
of undisturbed hearing were enjoyed. In 1873, the hearing
began to grow worse, apparently without any exciting cause, but
the bony tumor was found to be increasing in size ; Dr. Knorre
then proceeded to remove the bony obstruction by boring and
chiselling. The obstruction was overcome by successively re-
moving parts of it with a drill and chisel, touching the bony
growth with hydrochloric and sulphuric acid, burning it with
a red-hot knitting needle, and filing down the free surface of it
by means of delicate files, smooth on one side, such as are used
by jewellers. Most of this treatment was attended with severe
pain, so that intervals of rest were rendered necessary on account
of the tenderness of the ear. The operations for removal were
commenced in June, and by the following January the free
surface of the growth had been so much removed as to give a
free space between it and the opposite wall of the auditory
canal, and the hearing became once more normal. The patient
attributed most of the success to the chiselling performed by Dr.
Knorre ; the other operations were performed by the patient
himself. Other forms of acquired obstruction in the external
auditory canal may be partial or total, and they may consist
of cutaneous bands, diaphragms of skin or bone, and of horny
growths.

Dr. Engelmann,[1] of St. Louis, has described a case in which a
bridge-like band of skin stretched across the external auditory
canal, from one wall to the other. This, he thought, was proba-
bly due to a union of two granular surfaces. Dr. A. H. Buck,
of New York, has described a similar case.[2] Dr. Roosa[3] found, in
a case of chronic suppuration of the middle ear, a cartilaginous
band stretched across the outer portion of the canal. Upon
division of this band, it was found to contain " scales of bone
which seemed to come from the posterior portion of the canal."

[1] Archiv f. Ohrenh., vol. ii., N. F.
[2] Transactions American Otol. Soc., vol. i. p. 536.
[3] Ibid., 1870, p. 90.

Cutaneous Closure of the Auditory Canal.—Cutaneous closure of the canal at any point appears to be more frequent than bony closure of the same. It may be congenital or acquired. This kind of obstruction in the canal is not always recognized at once, especially if the diaphragm of skin is stretched across the canal near the fundus; in such a position, the obstruction may so closely resemble a thickened drum-head as to lead to some confusion in diagnosis.

Dr. Morland[1] has described a case of congenital imperforation of the auditory canal, caused by a cutaneous diaphragm in the cartilaginous portion of the canal, with hyperostosis of the bony portion. In this and in other cases the imperforation was not discovered until disease and deafness in the other ear drew attention to the imperfect hearing in the imperforate ear.

In this case, the external ears were well formed. The occluding cutaneous layer in the auditory canal appeared to be a "perfectly natural and smooth extension, or prolongation from the common covering of the auricle. It was not red nor uneven, nor as if thickened by previous or existing disease; but white and uniform in appearance with the surrounding skin."

After the patient was etherized, a crucial incision of the occluding cutaneous diaphragm was made, and the four resulting flaps were removed with small curved scissors. An aperture, "about as large as a crow-quill," was made, through which a probe was cautiously passed, until it impinged against what was probably the drum-head. The lining of the meatus appeared normal, but there was considerable hyperostosis in the bony portion of the canal. No view of the inner portion of the meatus could be obtained. A piece of compressed sponge was then inserted, and subsequently sponge-tents were inserted, and the ear cleansed every few days, by the family physician of the patient. By Dr. Morland's advice, a gold tube was also worn in the meatus, and the ear healed in two months, with good hearing.

Dr. A. H. Buck[2] has recorded the case of a young woman, 26 years old, affected with otorrhœa in the right ear in childhood, in whose right auditory canal he found "a smooth parchment-

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[1] Transactions American Otol. Soc., 1870, pp. 31–34.
[2] Ibid., vol. i. pp. 536–537.

like membrane of slight but uniform concavity, outwardly." It had a translucent appearance, with no evidence of being provided with vascular supply, and it was tough and decidedly thicker than the membrana tympani. When this was pressed upon by a probe it yielded with a crackling sound, audible even to the by-standers. This horny diaphragm was continuous with the skin of the meatus at all points.

A free crucial incision was made through this membrane, and it was found to lie about a line on the outer side of the normal plane of the membrana tympani. Through the incision thus made by Dr. Buck, the red and succulent mucous membrane of the promontory was all that could be seen at first beyond the diaphragm.

As an evidence of the vitality of the false membrane, it is stated that "at the end of the examination a glistening border of bloody serum was noticed along the cut edges of the triangular flaps. At a subsequent visit it was ascertained that the malleus was still present, its tip being adherent to and covered by the tissues of the promontory. The short process of this ossicle could be distinctly recognized at the inner edge of the base of the false membrane, which had now become "a simple constriction with sharply cut edges."

Dr. Buck states that subsequent to his publication of this case, he learned from Dr. Simrock, of New York, that the latter had seen three cases of false membrane, resembling the one just quoted, in one of which the membrane lay much nearer the external orifice of the auditory canal.

In some cases polypoid growths, invading the same transverse plane of the auditory canal, may grow together, and skin forming over them, a diaphragm is formed, which stubbornly occludes the canal at that point. Beyond the diaphragm the passage may be normal.

In some cases an orifice is found in the centre of this diaphragm, and by dilatation of this the diaphragm may be reduced to a constriction simply, and then the latter carefully widened.[1]

In such a case the constriction may be overcome by an application of nitric acid, made only once, as in the case of Dr. Buck referred to.

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[1] See case by Dr. Buck, Transactions American Otolog. Soc., vol. i. p. 538.

Dr. C. J. Blake[1] has met tumors of a horny nature in the auditory canal. These growths closely resemble the cornua humana. (See p. 231.)

Epileptiform Symptoms from Irritation in the Auditory Canal.—It is well known that irritation set up in the auditory canal by the presence of a foreign body will produce epileptiform and even paralytic symptoms. This is amply confirmed by the experience of Fabricius Hildanus, Toynbee, Von Troeltsch, Wilde, Handfield Jones, Hillairet, Moos, and others. It therefore becomes of the highest importance to examine the ear among other organs in a case of epileptiform disease of doubtful origin. The possibility that the ear or a foreign body in it may have something to do with the case in question should lead every physician to examine this organ or have it examined. It would be but safe to examine the ear as often as the pupil of the eye.

Ear-cough.—Ear-cough, a name recently applied by Dr. Fox, of Scarborough, England, to a peculiar reflex cough, excited by irritation of the external auditory canal, was known to medical men a long time ago.

In the celebrated case, given by Fabricius Hildanus (1596), among the various reflex neuroses mentioned as the result of irritation of the external auditory canal by the presence of a glass bead, was a peculiar dry cough.

Tissot[2] wrote of this peculiar cough as generally known in his time, and narrates an instance of it in " a French gentleman who consulted him for total deafness, but whose external auditory canal he could not touch, without occasioning a violent cough (toux très forte), which was absolutely uncontrollable." He also states that Etmüller (Francofurti, 1696–97) had observed, that, by touching the external auditory canal with a probe, one could produce a dry cough, which the latter attributed to the " sympathy between the nerves of the ear and those of the trachea."

Pechlin[3] regarded the peculiar cough (ear-cough) arising from

[1] Trans. Amer. Otolog. Soc., vol. i. p. 538.
[2] Traité des Nerfs et de leurs Maladies. Paris et Londres, 1780, pp. 54–56.
[3] Observationum Physicomedicarum Tres libri, Io. Nicol. Pechlini, Hamburgi, anno M.DC.XCI., Lib. 2, obs. 45—quoted by Tissot, op. cit., p. 55.

irritation of the external auditory canal as a common occurrence, but mentions as a rarity a peculiar reflex sympathy ("consensus") existing between the ear and the stomach (l'ouïe et l'estomac), a striking example of which he observed in a military officer, who vomited considerably whenever his extremely sensitive external auditory canal received the slightest touch even of the finger.

With the object of ascertaining the percentage of those subject to this sympathetic peculiarity, Dr. Fox carefully examined one hundred and eight persons: males, thirty-seven; females, forty-five; sex not noted, twenty-six.

His conclusions are as follows:—

" 1. From amongst the unknown group of idiopathic coughs, may happily be rescued from obscurity a cough which is excited by an irritation of the meatus auditorius externus in certain individuals.

" 2. The persons referred to are those who possess a hyper-æsthetic condition of the nerve supplying that canal, and in whom any slight titillation of this nerve induces a feeling of tickling in the throat.

" 3. This hyperæsthetic state generally exists in both ears, sometimes, however, only in one, and occurs in about twenty per cent. of those examined.

" 4. Its existence can usually be traced to childhood, and is probably a congenital peculiarity.

" 5. The nerve of the ear concerned in the production of ear-cough, is not a branch of the vagus, as Romberg and Toynbee have affirmed, but is a branch of the auriculo-temporal branch of the fifth cranial nerve.

" 6. This sympathy between the ear and the larynx is an example of a reflected sensation, in which the connection between the nerves involved takes place in the floor of the fourth ventricle.

" 7. Vomiting is occasionally, but rarely, the result of the application of an irritant to the nerve distributed to the auditory canal."

Sometimes otitis externa diffusa will also produce the most obstinate ear-cough. The attacks may not be frequent, but they are severe and distressing, not uncommonly ending in vomiting.

Bleeding from the Meatus.—Hemorrhage from the ear occurs not uncommonly from traumatic causes which apparently produce no further lesion. A physician informed me recently that, slipping suddenly, he struck his mastoid process violently on a projection of some kind in his office. The blow was followed by hemorrhage from the meatus, but by no further trouble.

Hemorrhage from the meatus, connected with injuries to deeper parts of the ear, will be considered further on, when alluding to injuries of the internal ear.

Bleeding from the ear has been observed in some instances of suppressed menstruation. It may be preceded by pain and a sense of fulness in the ear, to which it will give relief.[1]

Treatment.—If the bleeding is due to an injury limited to the skin of the external canal, a mild styptic may be required. In any event the blood must not be allowed to form permanent clots or crusts in the meatus.

[1] Hinton; Questions of Aural Surgery, p. 97.

SECTION IV.

MEMBRANA TYMPANI.

CHAPTER I.

ACUTE AND CHRONIC INFLAMMATION, INJURIES, AND MORBID GROWTHS.

Acute Myringitis.—In many cases it may be of great clinical convenience to speak of an inflammation of the drum-head; but, anatomically, it is not easy to describe such a disease of the ear. By many it is regarded as one of the rarest of aural maladies, and some authors deny its existence.

Being so intimate in structural relation with the external auditory canal on one side, and with the tympanum on the other, it is to be supposed that disease in either of these parts may very easily extend to the drum-head; but as the middle or fibrous layer is the only layer peculiar to the drum-head, and as it has no nervous and vascular supply of its own, it may indeed be said in safety that a true myringitis rarely if ever occurs. Nevertheless, it is often observed that an inflammation of the external auditory canal may localize itself in the outer layer of this important partition between the outer and middle ear. Perhaps, too, an inflammation of the mucous membrane of the middle ear may localize itself on the inner surface of the drum-head. Hence, clinically, many of the best observers prefer to tabulate myringitis among the diseases of the ear, for the fact is that an inflammation of the skin of the external canal or of the mucous membrane on the inner surface of the membrana tympani, having culminated in the drum-head, will produce such modifications in that membrane as to demand attention somewhat different from that obtained if the inflammation occurring in these constituent structures had localized itself elsewhere.

Hence it is found that Dr. Blake and Prof. Gruber[1] have drawn especial attention to this disease, as far as it can be termed an independent one, in their clinical teachings. The latter repeats what he has stated in his treatise on the ear, that as an idiopathic disease myringitis is of rare occurrence; as a secondary event very frequent.

Symptoms.—A typical case of so-called myringitis is characterized by pain and tinnitus, but not intense hardness of hearing. Upon inspection it will be seen that the membrana tympani is congested, usually very greatly if the disease has advanced, but that its position is not abnormal, and that the adjacent wall of the auditory canal is little or not at all congested. At the same time the Eustachian canal may be found entirely free, and, if the membrana tympani be cut through, it will be found that there is no secretion in the tympanum. Hence, then, there may be an inflammation localized in the membrana tympani, the external auditory canal and the middle ear being free from inflammation. It would seem but fair to give the name of myringitis to such a disease, and mark out for it a special treatment.

By further watching such a case, it will be found that the membrana tympani becomes gradually thicker from infiltration, and at last pus will be found on the outer surface, without the existence of a spontaneous opening in the membrane. By wiping away this product of inflammation, the outer surface of the membrane will be found very red, in some cases almost raw, and it will bleed if touched roughly. This condition of breaking down may go on to a perforation by erosion, apparently from without inward, and an ulcerated spot may at last form on the outer surface of the drum-head. The hearing in the mean time, however, does not suffer as it does when the tympanic cavity is affected by disease. As I have assured myself, by means of the catheter and by incisions through the drum-head, that the tympanum is free from disease in all such cases as could be termed myringitis, which I have seen, I am disposed to consider so-called myringitis an inflammation usually, if not always, of the dermoid layer of the drum-head.

I have seen so many of these cases, arising from external cold,

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[1] Monatsschr. für Ohrenheilkunde, Nos. 9, 11, and 12, 1875.

that I am inclined to the above view of their nature. If the mucous surface only of the membrana tympani is inflamed, it is not easy to make such a delicate diagnosis, and, furthermore, there is no proof that inflammation would remain localized on the inner as it does on the outer surface of the membrana tympani. Doubtless, localized inflammation does occur on the inner surface of the drum-head, but the symptoms it produces are not as distinctive as those produced by inflammation of the dermoid layer.

The symptoms of acute myringitis may be learned from the following case, which will also show the clinical significance of the disease :—

A gunsmith, a large, healthy man, 40 years old, complained of some earache, considerable deafness, and marked tinnitus in his left ear, all of which he attributed to exposure to cold air on that side of the head for several hours, while at work. On inspection, the membrana tympani was found reddened, dry, scaly, and somewhat thickened, i. e. it looked more like a piece of thick sheepskin than the delicate normal drum-head. The hearing was found to be $\frac{0}{60}$ in. for small watch. Tuning-fork, on vertex, heard best on affected side. The position of the membrane did not seem altered, but, as the latter looked thick, and as I suspected there might be retained secretion in the tympanum, the membrane was incised: nothing but air came whistling through the cut when Valsalva's inflation was performed. The hearing improved slightly. The perforation healed in a few hours, and the next day the hearing was reduced again to $\frac{0}{60}$ for the watch. The pain, though slight, continued ; the membrane looked more swollen ; the tinnitus was still annoying. In the course of two or three days, the man presenting himself at the infirmary, the membrana tympani was found to be covered with a film of pus, beneath which the membrane was quite red. The pain had now become less. Under instillations of zinc and opium, the secretion ceased, the drum-head healed, and the hearing returned, without there having been any symptom of disease, excepting in the dermoid layer of the membrana tympani.

Differential Diagnosis between Acute Myringitis and Acute Otitis Media.—The disease most likely to be confounded with acute myringitis is acute inflammation of the middle ear, but it will

be found that there are some very characteristic features by which the one may be distinguished from the other. In acute otitis media there is found, early in the disease, an indrawing of the membrana tympani, without thickening, and the redness is limited to the manubrial plexus and the upper periphery. In acute myringitis, however, the membrane becomes first rough and evenly red all over, then thick and infiltrated, but not indrawn; rather flattened than otherwise, or its position remains very nearly normal. The pain in otitis media is intense, while in acute myringitis it is not so terrific. In the former disease, the secretion forms within the tympanum, and there is consequently a marked tendency to perforation of the membrana tympani from within outward. In acute myringitis there is no special tendency to perforation, though there may be such an occurrence in the membrane, by erosion from without inward. Then, further, the secretion in otitis media is copious, and it may be either of a mucous or purulent nature. In acute myringitis, however, it is scanty and purulent. In the former, the febrile and constitutional symptoms are severe and often grave, while in acute myringitis, such severe symptoms are wanting. These facts, added to others previously mentioned, would seem to warrant a conclusion that there may be, at least clinically, an independent disease, which may be termed acute myringitis.

Etiology.—The most usual cause of myringitis is sudden exposure of the drum-head to cold. This may occur either from blasts of cold air on the drum-head or from exposure of it to sudden cold in plunging or bathing in cold water. The latter exposure is most commonly incurred at the seaside bath. The disease may also be caused by instillations of irritating fluids into the auditory canal or by violence from any source.

Treatment.—The treatment indicated in the acute stage is depletion of the congested membrane. Leeching near the ear will give relief, but a quicker way is scarification of the membrana tympani, as suggested by Dr. Blake. From two to four cuts may be made in each case, the points selected for incision being those of greatest prominence or congestion. Care must be taken not to cut through into the tympanic cavity. Relief is obtained, as a rule, by one scarification. I have

practised this form of treatment, with success, in acute cases. In those which are more chronic, the disease must be treated chiefly by cleansing with warm water and weak solutions of zinc and opium.   An ordinary wash of zinc, gr. j–ij to f̄ʒj, will in most cases be sufficient. If the disease tends to become chronic, it will be necessary to touch the surface of the diseased membrane with nitrate of silver, in order to prevent the dermoid layer from becoming ulcerated.   If granulations form they may be touched either by strong solutions of silver or by the saturated solution of chloroacetic acid.

CHRONIC INFLAMMATION.

Ulcers in the Dermoid Layer.—As a consequence of acute external otitis or of acute myringitis, ulcers may form on the membrana tympani.   As has been intimated when alluding to acute myringitis, erosion of the dermoid layer of the drum-head may occur in that disease.   The first stage of such erosion would implicate the outer layer, while subsequent advances of the disease would involve the deeper layers.   Hence, an ulcer on the drum-head may assume a terraced shape, the upper stratum being the dermoid, the middle, the fibrous, and the inner, the mucous layer of the membrana tympani.

Most usually, however, the ulcerative process on the drum-head does not pass beyond the two outer layers.   That true ulcerative processes do occur here, has been fully shown by J. Orne Green.[1]

Symptoms.—The symptoms of such a process on the drum-head may be attended with no very great loss of hearing, but there is usually some tinnitus aurium, but pain is entirely absent.   The attention of the patient is called to the ear by more or less hardness of hearing and the subjective noise, but chiefly by the scanty and slow discharge.   The latter features of the discharge lead to a hardening of it about the meatus, and the ear, feeling dry and stiff, the patient is inclined to pick at it.   By such manipulation, dry scales of dark matter are pulled

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[1] Ulceration of dermoid layer of membrana tympani.   Trans. Amer. Otol. Soc., vol. i. p. 431, 1873.

from the meatus, and are usually another incentive to the patient to seek medical aid.

Causes.—This ulceration of the dermoid and other layers of the membrana tympani, I have uniformly found in the poorly nourished classes of the Infirmary. A process in the external ear, especially on the outer surface of the membrana tympani, which otherwise would run an acute course and then disappear, tends to become chronic in the poor and the unclean. In addition to poverty and uncleanliness, there must be added ignorant neglect or improper domestic treatment, the latter consisting chiefly of instilling oils which clog the ear and become rancid, or by the direct instillation of irritants of various kinds. It can be seen how readily all these circumstances tend to provoke, in the cachectic especially, a chronic ulceration in the external ear. For it is a skin disease, a cutaneous ulcer, that is to be contended with in such cases.

Prognosis and Treatment.—The prognosis is favorable if the proper treatment is carried out, but, like every other aural disease, this tends to chronicity in the most favorable circumstances if not properly managed.

Should the condition of the patient demand constitutional remedies (and it always will, according to my observation), some form of iron will be found of great benefit. The syrup of the iodide of iron, or some one of the numerous preparations of iron and cod-liver oil, will render good service in these cases.

The local treatment is of the greatest importance in ulceration of the membrana tympani. The auditory canal must be carefully cleansed by syringing with warm water often enough to prevent accumulation of matter. But the secretion in these cases is not usually copious. It is, however, tenacious, and the patient does not seem able to remove it thoroughly by syringing. It is, therefore, of prime importance that the surgeon should wipe off the drum-head and inner end of the canal, by means of the cotton holder. This should be done very carefully and thoroughly, under good illumination of the canal, by means of the forehead mirror. To attempt to cleanse an ear by swabbing it out, without such illumination, is worse than useless; it is always painful, and most usually dangerous.

The perfunctory custom of turning the sufferer's ear towards a window, and blindly forcing into it a probe, armed or un-

armed with a tuft of cotton, or a brush, is almost culpable. The canal varies enough in every patient to warrant special illumination, by means of ear-funnel and forehead mirror. By this means the curves in the canal are not struck and wounded, as they are when the canal is manipulated in a less desirable way. After the canal is properly lighted and the membrana tympani perfectly visible, let the latter be wiped off by means of a tuft of cotton on the flexible cotton-holder. When the ulcerated membrane is thus cleansed, the local remedies may be applied. These may consist of applications of nitrate of silver or of sulphate of copper. Dr. J. O. Green has found the latter very beneficial in ulceration of the dermoid layer of the drum-head. Nitrate of silver is best employed in solution; it may be either instilled into the ear and allowed to find its way to the fundus of the canal and the drum-head, or it may be applied by means of cotton on the holder, directly to the diseased spot. Solutions of sulphate of copper may be applied by means of the cotton-holder, or the solid crystal may be used. Dr. Green prefers the latter to the nitrate of silver in any form, in these cases.

Insufflations of powdered crude alum, equal parts of magnesia and salicylic acid, and equal parts of alum and iodoform may be of great advantage if the disease should appear to be spreading to the adjacent walls of the canal with increased amount of secretion. But cleanliness is the chief consideration; then stimulation of the sluggish ulcerated parts, and, if they appear to be disposed to pursue a less sluggish course, simple astringents may be employed. The latter should be the sulphate of zinc in weak solutions (gr. j–ij to f℥j) with a little wine of opium or laudanum. The prescription I am most likely to use in these cases, if only a weak astringent instillation is needed, is:—

R.—Zinci sulphatis, gr. j–ij ;
Tinct. opii, fℨj ;
Aquæ, f℥j.—M.

Of this mixture 10–12 drops may be instilled warm into the ear twice or thrice daily after syringing. For the zinc, a grain of sulphate of copper may be substituted. But no specific treatment can be laid down; each case must be studied and guided back to health.

Perforation of the Membrana Flaccida.—Perforation of Shrapnell's membrane, or the membrana flaccida, appears to be an uncommon occurrence. It is usually found to be the result of chronic disease, and is invariably attended with great hardness of hearing. Most probably the ulcerative process attacking this part of the membrana tympani also greatly implicates the joints of the ossicles. Dr. Blake has recorded two cases[1] of perforation of the membrane of Shrapnell (membrana flaccida), one of which was the only perforation in the membrana tympani, and the other, a very small one, was associated with a larger perforation in the inferior segment of the membrane. Through both of these perforations a discharge existed. In the first case, small polypoid growths surrounded the neck of the malleus, in the other the fundus of the canal was filled up by a soft polypus, the removal of which revealed the presence of the two perforations. So far as I know, Dr. Blake's case of double perforation of the membrana tympani, one of the openings being in Shrapnell's membrane, is unique. I have seen five cases of perforation of the membrana flaccida, all of them large, but unassociated with perforations elsewhere in the membrana tympani. As accounts of cases of this nature are not common, it will not be amiss to give in detail those observed by the author.

CASE I. *Chronic Discharge from the Tympanum, with Perforation of the Membrana Flaccida posteriorly.*—John M., 17 years old, came under my care in the Presbyterian Hospital of Philadelphia, in July, 1872. He states that his first ear-trouble occurred when he was four years old. He is a pale, intelligent lad, a hard student in a classical school. His father died insane, and he has a brother who is hopelessly insane. When the patient was twelve years old he began to have " gatherings in his ear" about twice each winter. A year before he became my patient, a constant and most copious discharge, preceded by pain, became established in the right ear. When I made my first examination of his ear, in July, 1872, the membrana tympani was found saturated with a yellowish-green pus. The only perforation in the membrana tympani was in the membrana flaccida, above and behind the short process of the malleus, but

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[1] Dr. C. J. Blake, Perforation of Membrane of Shrapnell in Otitis Media Purulenta ; vol. i. Trans. Amer. Otol. Soc., p. 546, 1875.

at no time was there a perforation-whistle obtained by any mode of inflation of the tympanic cavity. The hearing was reduced to $\frac{6\ in.}{50\ ft.}$ for the watch, and for the voice, nil. I passed a probe a short distance into the perforation. The cavity was sensitive, and there was no denuded bone. The treatment consisted of instillations of a solution of nitrate of silver (80 gr. to f℥j) once a week, at the hospital, and the patient was ordered to syringe his ear three times daily at home, and to instil a solution of zinc (gr. x to f℥j). For the latter solution were sometimes substituted solutions of alum, and later a solution of nitrate of lead. In four months the discharge ceased, the nitrate of lead apparently having had the best effect on the aural disease in this case.

In November, five months from the beginning of treatment, the membrana tympani had assumed an almost normal appearance, except the cicatrix in the membrana flaccida.

At no time were there any granulations, and the discharge remained, uniformly, of a light color, and of the consistence of cream. The hearing improved to $\frac{50\ in.}{50\ ft.}$ for the watch, and the voice could be heard close to the affected ear. The Eustachian tube was pervious.

On the first of January, 1873, the patient was found complaining of pain and soreness in the mastoid process of the affected ear, but he had no symptoms of fever. Perfect physical rest, with attention to general health, was ordered, and by the 10th of the month all mastoid symptoms had vanished. There was no return of the discharge as the pain subsided, but, as the patient was studying too much at his school, his health began to fail, and he was therefore ordered to quit school and take as much exercise in the open air as possible.

By the 1st of December, 1873, the discharge returned, with pain in the ear and soreness when the auricle was pulled gently. The discharge continued for three months and a half, with persistence of the old perforation in the membrana flaccida. I could readily see the discharge oozing slowly from the perforation, after drying the orifice with the cotton-holder.

At this second attack of discharge from the ear, the strength of the solution of nitrate of silver was increased to 480 gr. to f℥j. This caused intense pain for a few minutes; then the pain ceased entirely. In conjunction with applications of the strong

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solution of silver, the patient used a strong solution of the sulphate of zinc (30 gr. to f℥j) at home, which seemed to exert a good effect in the course of one month. The most careful syringing became necessary while using this strong solution of sulphate of zinc, in order to remove the coagula produced by it. A few painful furunculi followed the cessation of the discharge.

On the 22d March, 1874, the voice and the watch were heard five paces. There was a depressed cicatrix in the membrana flaccida, above and behind the short process. The membrana tympani, below the folds, was almost normal in color.

Dr. J. Orne Green[1] has called attention to this variety of purulent inflammation of the tympanum, in a paper read before the Boston Society for Medical Improvement, Dec. 22, 1873. He says, " While in the common purulent inflammation of the tympanum, the pus secreted by the mucous membrane which lines that cavity finds an exit by rupturing the drum-membrane, either in the anterior or posterior segment, somewhere about its centres, I have seen a few cases where the rupture has occurred in the extreme upper portion of the membrane, the membrana flaccida, and these have been so obstinate under treatment, and so serious, that I desire to direct special attention to them."

Dr. Green then alludes to five cases occurring in his practice, two of which he describes minutely. There are many points of resemblance between Dr. Green's cases and the case just given, viz., " the intensity of inflammation confined to the upper portion of the tympanic cavity; that is, the lower portion of the tympanum was never filled with pus, nor was any congestion seen, except in the neighborhood of the perforation;" it was also a noticeable fact that no perforation-whistle followed the perfect inflation of the tympanum in these cases.

The following features, however, seem to characterize my case, but do not appear to have been prominent in Dr. Green's cases. This case came on with attacks of great pain, while the patient was a child; there was no denuded bone; the perforation in the membrane was just large enough to admit the small round head of a silver probe, and there were from time to time attacks of pain and throbbing in the affected ear, and finally the discharge ceased under the use of astringents, in stronger solutions after

[1] Boston Medical and Surgical Journal, March 26, 1874.

the relapse, than at first: there was marked hardness of hearing, but no tinnitus at any time.

It is of interest to note that the first cure was effected in the autumn of 1872, with no relapse until the winter of 1873–74. In the winter of 1872–73, there were simply ten days of mastoid soreness and pain, with no discharge. The patient has resumed his studies at school, and has gained in stature, strength, and hearing.

Throughout the previous history of this case there is a tendency to recur; but during the two years he has been my patient, he has had only eight months of aural discharge, viz., the first four months, which were followed by one year of freedom from aural discharge, and then a recurrence of otorrhœa for three and a half months, which brings the history to March, 1874, since which date the patient went to reside in another city.

The patient remained away, and did not give any report of himself until November 26th, 1875, when it was found that the discharge had returned, and that a small polypus was protruding from the perforation in the membrana flaccida. The polypus was easily removed, but its precise point of attachment could not be determined. A small piece of cotton on the holder was moistened with chloroacetic acid and passed through the perforation, and thus near to the attachment of the polypus. The patient has passed from observation on account of his residence in a distant city, though from his accounts it may be inferred that the ear is doing well.

CASE II. *Perforation of the Membrana Flaccida.*—A second case of perforation of the membrana flaccida (Shrapnell's membrane) was observed in a man 22 years old. He stated that the first symptom in the affected ear, the left, was an attack of pain which had occurred seven months previous; this was followed by a discharge, which had gradually become less. Becoming anxious to have it entirely checked, he had applied for treatment.

The perforation was large, embracing most of the flaccid membrane, and exposing the neck of the hammer. The discharge was very slight. Unfortunately for the further history of this case, like many others seen in public practice, it passed from notice after the second visit. The hearing in this case was greatly impaired.

There was no perforation-whistle produced in this case at any time by any mode of tympanic inflation.

CASE III. *Perforation of the Membrana Flaccida; Polypus protruding through the Opening thus made.*—A third case presents more clinical interest, as it has been long watched (Sept. 7, 1875), and is still under observation. The patient, a German woman, 35 years old, stated that two years previously her left ear had troubled her for the first time. There was then some pain followed by an offensive discharge; the latter had continued, greatly to her annoyance. The hearing was reduced to $\frac{3 \text{ ft.}}{60 \text{ ft.}}$ for the loudly-ticking watch; for the voice, similarly. The meatus was found smeared with a slight but offensive discharge which came from a large perforation in the flaccid part of the membrana tympani. The membrane was not perforated elsewhere, but it appeared abnormally thickened, as it always does, so far as my experience goes, when a perforation exists in the membrane of Shrapnell. A polypus as large as a small pea protruded through the perforation. The attachment of the polypus was inside the tympanum, posteriorly; when it had been removed, which was easily done with a hook, it was found that the polypus attached posteriorly had grown forward between the membrana tympani, *i. e.* the region of the perforation, and the contents of the upper part of the tympanic cavity. Its inner surface was flattened; its outer surface, being free to grow out through the perforation, had assumed a convex shape, and this it was that was seen protruding through the opening in the membrane.

There was no perforation-whistle at any time. The ear was kept carefully cleansed, and chloroacetic acid was applied by means of the cotton-holder to the perforation and the tympanic cavity adjacent to it. The patient syringed the ear well two or three times daily at home, and instilled a weak solution of zinc. The discharge diminished greatly, lost its fetor, and at last ceased entirely. The hearing has not materially improved, as indeed might be expected, when it is remembered how near the articulations of the ossicles the brunt of the disease must have fallen. Indeed, I have yet to see a perforation of the membrana flaccida unattended with great deafness. The latter and the loss of substance in the drum-head appear to be due to the same cause.

CASE IV. *Perforation of the Membrana Flaccida, probably from External Causes; Foreign body in the Canal.*[1]—This case, besides presenting the comparatively rare occurrence, perforation of the membrana flaccida, also furnishes an example of the still rarer feature of being probably caused by external erosion. The patient, a Scotchman, 35 years old, complained of an intense pounding noise in the right ear, which caused him much annoyance, and brought on frequent attacks of headache and dizziness. In the diseased ear the watch was heard only in contact with the auricle. His aural discomfort, which had become especially annoying to him within several years, had led him to pick at his right ear, from which he had now and then brought "small pieces of something which had an offensive odor." He was entirely unsuspicious of the presence of a foreign body in the ear.

The examination of the ear revealed an apparently free auditory canal, but a very much thickened and irritated yet imperforate membrana tympani. From the line of the folds of the latter and the short process, over the region of the membrana flaccida and the inner portion of the upper wall of the auditory canal, there seemed to be dark adherent wax. Upon laying hold of this obstruction, it was easily removed, and proved to be a grain of corn imbedded in cerumen. The place occupied by this mass was very much altered in appearance. From the line of the folds of the membrane to the segment of Rivinus, *i. e.* the region of the membrana flaccida, appeared much more extensive and sunken than usual; from the segment of Rivinus outward along the upper wall for one-eighth of an inch, the bony roof of the auditory canal seemed greatly hollowed out, into a dome-like space, and here the major portion of the grain of corn was lodged.

The membrana flaccida appeared to be gone; at the place usually occupied by it there was a whitish, roughened, cicatrized depression, bounded below by the distinct upper edge of the membrana tympani proper.

Upon inflation the membrana tympani below the folds bulged, but no air escaped from the region of the flaccid portion. The membrana flaccida had been eroded apparently by external pressure in this case.

[1] See also Proceedings of Pathological Society of Philadelphia, 1876.

The foreign body had been in this man's ear probably twenty-five years, as gleaned from the apparently trustworthy history of his life.

The membrana tympani below the folds may be perforated from external pressure and consequent irritation, and it would seem fair to conclude that the same process may go on in the membrana flaccida. The latter, however, being protected by its high position from pressure from a foreign body in the canal, is not as likely to be perforated from such external causes as is the membrana tympani below the folds. Upon the removal of the foreign substance from the ear in this case, the subjective noise and the disagreeable head symptoms ceased, but the hearing was not improved, which would seem to show that the impairment of this function was due to a process of disease in the tympanum, probably in its upper part, in the region of the membrana flaccida, and not dependent upon the presence of the foreign substance.

Case V. *Ulceration of the Membrana Flaccida, from External Irritation.*—This case, without presenting a membrana flaccida entirely perforated, was unmistakably one of ulceration of this part of the membrana tympani, due to pressure of a plug of hardened cerumen. The patient, a man 40 years old, complained of dull aching in the ear of several days' duration; the hearing was only slightly diminished. Upon inspection the canal was found to be filled with cerumen, and the membrane consequently hidden from view. After removal of the obstructive mass, the only change observed in the drum-head was an ulcerated spot in the membrana flaccida, immediately above the short process of the malleus. This ulcer was about 1.50 mm. in diameter, and bled slightly on being touched; it was tender on gentle pressure. The ear was let entirely alone for a week, at the end of which time the ulcer had healed, and the ear had resumed its entirely normal function. This case furnishes an example of the fact that the membrane of Shrapnell may be ulcerated from without.

TRAUMATIC INJURIES OF THE MEMBRANA TYMPANI.

The membrana tympani is liable to a number of injuries from without. These, while not directly interfering greatly with

the function of hearing, usually expose the mucous lining of the tympanic cavity to the direct irritation of the external air, and thus lead secondarily to inflammation and loss of hearing.

Prominent among the causes which lead to traumatic rupture of the drum-head may be cited, boxing the ears, and receiving the force of a wave on the ear while bathing in the sea. The healthy membrane will usually resist these forces, but of course one which is in any way diseased by fatty degeneration, atrophy, and by calcareous deposits, or one prevented from assuming proper equilibrium by a closure of the Eustachian tube, is extremely liable to yield to external violence above named.

The drum-head may receive very injurious concussion from diving into the water, from the discharge of musketry or of a cannon, from falls, from a gunshot wound near the ear,—for example, in the upper maxilla and the horizontal plate of the ethmoid;[1] also from the kick of an animal on the mastoid process, and from the sudden introduction of long and slender instruments or implements into the auditory canal.

In the case of a young man, 21 years old, killed by a fall from his horse, upon a pavement, the left membrana tympani was found to have been fissured in the posterior half. The length of the fissure was $2\frac{1}{2}$ mm.[2]

In some cases of traumatic rupture of the drum-head, the primary wound is followed by symptoms of aural vertigo, as has also been noted by others.[3] The following case shows that there may be such a liability :—

John M., Englishman, married, 30 years old; the patient looked thin and somewhat anxious when he presented himself for treatment. The history given was, that the evening before, while sitting quietly reading, a companion playfully boxed him on the ear. Instantly he felt a roaring in the ear, but fortunately did nothing in the way of pouring in fluids with the

[1] Casuistische Beiträge zu den traumatischen Verletzungen des Trommelfells. Dr. E. Zaufal. Archiv f. Ohrenheilkunde, B. i., N. F. pp. 188, 280, and B. ii. p. 31.

[2] Trommelfellbefund nach Sturz mit dem Pferde. Dr. Trautmann. A. f. O., B. ii., N. F., p. 101.

[3] Fall von traumatischer Ruptur des Trommelfells mit Symptomen von Labyrinthreizung. Dr. Parreidt. A. f. O., Band ix. p. 179. Dr. Holmes; Trans. American International Otological Congress, 1876.

view of relieving the noise and hardness of hearing. The following morning it was found, on inspecting the membrana tympani, that it was ruptured in the posterior and lower part; that the diameter of the perforation was about 2 mm., and that there was little or no congestion in the drum-head. The patient had suffered greatly from heat of the previous night (it was July), and had been exhausted by nursing a sick infant. Upon his rising suddenly in my office, he grew very pale, said he was dizzy, and fainted. It was a long time, an hour or more, before he could go home, and then only in charge of an attendant. He remained very dizzy all day, but, the perforation healing in the course of a few days, the hearing became good, but not entirely normal, and the symptoms of dizziness disappeared.

Had the perforation by taking away some of the power the drum-head has of resisting the traction of the tensor tympani, allowed the latter to draw the chain of ossicles inward, producing temporary pressure in the labyrinth, with consequent dizziness?

The membrana tympani has been found ruptured in those who have been executed by hanging. Dr. Ogston[1] has described such a case in which the fissure of the drum-head was ragged, and running from the tip of the manubrium downward towards the periphery of the membrane. The edges were everted, but there was neither blood nor any other fluid in the cavity of the drum. From the eversion of the edges in such a case, it might be supposed that the force which breaks the membrane acts from within the tympanic cavity outward. The rupture of the membrane in such cases may be explained by supposing that the air in the tympanum, at the moment of the fall, is thrown into violent concussion, and, not being able to escape by the Eustachian tube, owing to the constriction of that canal by the rope, it is forced violently outward, producing the fissure of the membrana tympani. The membrana tympani may be ruptured by an increase in the atmospheric pressure, if the latter is very extraordinary, and if the Eustachian tube is more or less impervious.[2]

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[1] Archiv f. Ohrenheilkunde, Band vi.

[2] Dr. John Green, " Condensed Air, 60 lbs. to square inch ; its Effects on the Eustachian Tube." Tr. Amer. Otol. Soc., vol. i. p. 129, 1870.

The membrana tympani is probably able to endure sudden pressure from without, as in discharges of artillery, musketry, etc., whether expected or not, only through the loose valve-like nature of the Eustachian tube. This seems fully shown by the observations and experiments of Rüdinger, Brunner, Lucæ, and the observations of John Green, referred to.

Fracture of the Handle of the Malleus.—There are a few cases of fracture of the handle of the malleus on record. This rare accident has been described by Ménière,[1] von Troeltsch,[2] and R. F. Weir:[3] the first observed it in the ear of a gardener, who had received a thrust from a twig, while working; and the second saw a fracture of this part of the malleus, resulting from the accidental thrusting of a penholder into the auditory canal. In both cases the manubrium appeared to have united. Dr. Weir's case presents the additional rarity of an ununited fracture of the manubrium. It occurred in an Irish laborer, in consequence of a fall from a height of fifteen feet, four months before Dr. Weir saw the case. The lower portion of the manubrium was seen to be distinctly movable upon the upper part, whenever the tympanum was inflated. The fracture occurred just below the short process; inflation restored the parts to their normal position, but displacement occurred again in about fifteen minutes.

Atrophy of the drum-head may occur in consequence of pressure, long kept up, by a mass of hardened cerumen. This process is favored if the Eustachian tube is at the same time closed.[4] It is not uncommon to find, in those suffering with chronic aural catarrh and deafness, hardened pieces of ear-wax in contact with the drum-head. Though such an obstruction may add nothing to the existing deafness, it may and often does produce sensations of fulness in the head and, at times, vertigo. Such cases are apt to escape detection, simply because the patients have given up all treatment, considering their cases hopeless, and are no longer under examination. Although the

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[1] Gazette Méd. de Paris, p. 50, 1856.   [2] Treatise on the Ear, p. 151.
[3] Ununited Fracture of Manubrium of Malleus, Tr. Amer. Otol. Soc., vol. i. p. 121, 1870.
[4] S Moos, Archives of Oph. and Otol., vol. i. pp. 321, 324, 1869.

deafness may remain unchanged after the removal of such masses of cerumen, the cerebral symptoms are greatly relieved.

Reproduction of the Membrana Tympani.—The popular impression, that the membrana tympani once perforated can never be healed, is a wrong one. The drum-head, on the contrary, has great power of healing and restoration, as shown by Dr. H. N. Spencer.[1] A simple slit in it will heal in a few hours if there is no inflammation in the drum-cavity. Larger, and even gaping, perforations, caused by disease, tend to heal, unless the disease in the tympanum keeps up and by its chronicity leads to a cicatrization of the edges of the opening in the membrana tympani. The tympanic disease behind the perforated drum-head should receive more attention than the simple perforation, which is but the vent for the hypersecretion resulting from the disease in the middle ear. It is, therefore, not only unwise, but harmful, to attempt to close, by stimulation of its edges, a hole in the membrana tympani. If one should succeed in doing it, so long as the mucous membrane behind it is diseased, the closing of the perforation would deprive the drum-cavity of a direct way of treatment of its diseased lining, and sooner or later the drum-head would give way again. It is not easy, however, to cause a perforation in the head of the drum to heal while disease exists behind or about it. In endeavoring to do this, by stimulation of its edges, the hole is most usually made larger.

In the *Philadelphia Medical Times* for May 10, 1873, No. 80, vol. iii., I reported a rare case of restitution of the membrana tympani after fifteen years of disease. The chief features of the case were as follows: On the last day of July, 1872, Christian L., a German, 15 years old, consulted me respecting a chronic discharge from his right ear. The disease dated from infancy, without any history of a discharge from the left ear. All the statements of the boy were corroborated by his father, who accompanied him. Examination revealed the presence of a copious, light-green discharge in the meatus. Upon removal of the obstruction in the canal, a large perforation was discovered in

[1] Case of Reproduction of the Membrana Tympani, Transactions American Otol. Soc., vol. i. p. 179, 1871.

the upper posterior quadrant of the membrana tympani. Hearing distance for watch one-fourth of normal amount. Eustachian tubes pervious to inflation by Politzer's method. After cleansing the auditory canal and middle ear as thoroughly as possible, I instilled ten drops of a strong solution of nitrate of silver (℥j–f℥j) into the ear. This was syringed out in a few moments, and the lad ordered to syringe his ear at home thrice daily, with warm water, and after each syringing to drop into the ear ten drops of a two-grain solution of sulphate of zinc warmed, and to allow the latter to remain in the ear five minutes. One week later I saw the boy; his ear was much better, and he was ordered to continue the treatment. By the middle of August, two weeks after he was first prescribed for, the discharge from the ear had ceased, and the hearing for the watch had increased to one-half the normal distance. A few days later, the perforation in the membrana tympani had closed, and the membrane, which at the time of the first examination was swollen and discolored, had assumed the normal lustre. The hearing had now become normal, and the drum-head was exquisitely restored.

Medico-legal Significance of Traumatic Injuries to the Drum-head.—After a blow has been received on the ear, either during a quarrel or in play, an action for supposed injury to the drum may be instituted to recover damages. The surgeon will be called on, in such cases, to decide, first, whether there has been an injury done the drum-head, and if so, how far it will impair the hearing. In the first consideration he must bear in mind that the drum-head may have been perforated before the blow was received, though the patient or complainant may or may not know it. The chronic perforation can be readily distinguished from the acute. If it should be determined, however, that a previously normal drum-head has been ruptured by a blow on or a thrust in the ear, it then remains for the surgeon to determine whether the hearing has been or will be impaired by the injury. The mere fissuring of a normal membrana tympani in the above way may not necessarily injure the hearing nor oblige the patient to give up his daily work. If, however, there has been a severe blow on the ear, the hearing may be impaired from concussion of the nerve in the labyrinth, which, though asso-

ciated with rupture of the drum-head, is not necessarily caused by it. If there has been no concussion of the inner ear and no inflammation set up in the drum-cavity, the ruptured drum-head will heal quickly if let alone, *i. e.* if nothing is dropped or poured into the ear. Ignorance on the latter score has led very often to the use of drops the moment a fissure in the drum has been noticed. The matters thus poured into the canal, having entered the drum-cavity through the perforation, have set up inflammation in the delicate mucous membrane of the middle ear, and disease has been established where otherwise, by letting the ear intelligently alone, the perforation would have healed in a day or two. Thus it might appear that the blow had caused disease in reality produced by improper treatment of the ear. If, in a case of asserted traumatic violence to the drum-head, deafness should be immediately discovered by the surgeon, it must be determined whether it has been produced by the same blow which has ruptured the drum, or whether it existed before. A temporary diminution of hearing is very likely to occur after a blow on the ear, hard enough to rupture the membrana tympani, but if great and sudden deafness comes on after a blow on a previously healthy ear, and if it remains for several days without signs of improvement, it must then be adjudged permanent, and the claim for damages must be in accordance with the facts. Even if it should be decided that the injured ear was not in a state of health before the blow, it would seem that all the greater claim could be made by the sufferer. In such a case, however, it must ever be borne in mind that it is not the fissure in the drum-head that has done the damage, but the concussion to deeper and more delicate nervous parts of the organ of hearing.

MORBID GROWTHS.

Wart-like Bodies on the Drum-head.—Wart-like excrescences on the membrana tympani, first described by Dr. Urbant-schitsch,[1] I have observed in but one case. There were in this case, that of a man 24 years old, two pale yellow warts about

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[1] Ueber eine eigenthümliche Form von Epithelialauflagerung am Trommel-fell, und im äusseren Gehörgang. A. f. O., B. x. p. 7.

a millimetre in diameter, on the upper and posterior quadrant of the membrana tympani. There seemed to be no explanation for their occurrence, unless it could be found in the instilling of various fluids, which the patient had practised on his own responsibility, for some time for the cure of deafness resulting from chronic catarrh of the middle ear. The constant irritation thus applied to the delicate dermoid layer of the drum-head may have provoked the growth of some of its papillæ into the above-named wart-like bodies.

Endothelial Cholesteatoma of the Membrana Tympani.

—As an antithesis of desquamative inflammation of the middle ear, Dr. Wendt[1] has described a new growth, which he calls genuine or endothelial cholesteatoma. The nature of this new growth is better understood when Dr. Wendt's investigations respecting the membrana propria of the drum-head are known. According to him this membrane consists of coarse and fine fasciculi; both are inclosed in hyaline tunics, which are very resistent and contain cells of various forms (endothelia). Sometimes the nuclei are unaccompanied by protoplasm, but usually the latter, of round, oval, and stellate form, is present. These forms are subject to change according to the position of the cells. Lymphatics are found in the interstices. Endothelial cholesteatoma was found by Dr. Wendt in the right middle ear of a man who had died of typhus fever. The macroscopic examination revealed the following conditions. "In the anterior inferior part of the inner surface of the membrana tympani, there was found a slightly rough hemispherical mass 1½ mm. in diameter; the transparent golden lustre was characteristic. The lower part of the tumor passed into the membrana tympani, the upper part projected, hemispherical in shape, into the tympanic cavity, and was united to the membrana tympani by a fold of mucous membrane. The growth, after displacing the rete Malpighii, extended outwardly at some points as far as the surface of the external auditory canal; at others it pressed upon the corium of the dermoid layer.

"The mucous membrane of the tympanum was swollen and

[1] Archiv f. Heilkunde, 1873, pp. 551–562 ; also abstract by Dr. Trautmann, Archiv f. Ohrenh., B. ix. p. 281.

hyperæmic. The malleus at its anterior surface was detached from the membrana tympani, but still united to it posteriorly. The membraua tympani was flattened and somewhat thickened, it contained several small, round perforations, its layer of epidermis was discolored and broken down, and its mucous layer was swollen and intensely injected."

The microscopic examination of this growth revealed the following: "The tumor is enveloped in a capsule of connective tissue ; the latter is loose at some points, stretched at others, runs parallel to the surface of the tumor, contains hæmatoidine, and is covered with cubical epithelium. The capsule covers the outer part of the tumor and that part of it which projects into the tympanum ; the lower part passes over into the pathologically altered substantia propria. The capsule is to be regarded as emanating from the mucous layer of the membrana tympani."[1] In the membrana propria numerous cavities filled with parallel and concentrically arranged, nucleated pellicles were found. The trabeculæ were separated by these accumulations. These cavities became larger in the neighborhood of the tumor, in which the trabeculæ ran parallel to the surface of the membrana tympani ; they also ran in curves and at various angles. They consisted of extensive fibrils of connective tissue, arranged in fasciculi and inclosed in opaque, cylindrical, nucleated sheaths. These trabeculæ were further united into coarser fasciculi. In the interstices the same pellicles were found as in the membrana propria.

In the upper and older portion of the tumor, numerous crystals of cholestearine and drops of oil lay upon the pellicles, indicating retrograde metamorphosis. The pellicles were found to surround concentrically the coarser trabeculæ ; some of the cells of the former were transparent, rhomboid or crenated in form, and contained an oval nucleus. The above described changes in the membrana tympani are adduced by Dr. Wendt as proof of the endothelial origin of this new growth.

Cholesteatoma of the Drum-head.—Among recent observers Dr. Küpper,[2] of Elberfeld, Germany, has described a

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[1] Review by Dr. Trautmann, loc. cit.
[2] Cholesteatom des Trommelfelles. A. f. O., B. xi. p. 18.

small tumor found on the membrana tympani of a man 30 years old, who had died of consumption. This small growth, $1\frac{1}{2}$ mm. in diameter, was situated below the umbo of the membrana tympani, and was easily removed by simply touching it with a needle. The little tumor was pearl-gray in color, and composed of several layers arranged like those of an onion. The microscopic examination showed that these were composed of layers of epithelium with here and there some crystals of cholestearine. Dr. Küpper thinks that ultimately this new growth might have penetrated the membrana tympani, and invaded deeper parts. He is not disposed, however, to thus explain the origin of every pearly tumor of the tympanum, for it is well known, as he says, that such tumors may grow in the tympanic cavity, the drum-head remaining entirely intact, as shown by Lucæ.

SECTION V.

MIDDLE EAR.

CHAPTER I.

ACUTE CATARRHAL INFLAMMATION.

ACUTE catarrhal inflammation of the middle ear is a process characterized by an increased formation of mucus, but which stops short of the production of pus. This increased amount of mucus in the middle ear usually escapes through the Eustachian tube, or by absorption; it rarely causes a rupture of the membrana tympani, for the tendency of acute catarrh is rather towards a swelling and a thickening than to a breaking down of tissue.

An acute catarrh of the middle ear, which advances to a perforation of the membrana tympani, will most commonly be found to have led to purulent products, for pure mucus alone is rarely found escaping through a rupture in the drum-membrane.

If, then, an acute catarrhal inflammation of the middle ear advances to the formation of pus, a more destructive form of inflammation, a purulent variety may be said to be present. While the latter condition must always be preceded in the middle ear by the former, catarrhal inflammation may have a distinct existence without the presence of pus.

For the sake of clinical convenience, the endeavor is made to describe two forms of acute inflammation of the middle ear, but the fact must not be lost sight of that very often these so-called forms are but stages of the same disease, and that, therefore, up to the point of succession, *i. e.* where the *mucous* symptoms are succeeded by the *purulent*, the symptoms and treatment are the same for both forms.

In fact all treatment in a case of acute catarrhal inflammation

of the middle ear is based an the hope of preventing the forma-
tion of pus, which is known to be only too likely to follow the
catarrhal or mucous stage.

Symptoms and Course.—The lightest form of acute catarrh of
the middle ear comes on during an ordinary cold in the head,
or from any other cause which produces only a slight swelling
and closure of the Eustachian tube.

In this light form it is little more than a congestion and slight
swelling of the mucous lining of the Eustachian tube, and per-
haps of that of the tympanum, accompanied by an unusual
amount of mucus. It may thus affect one or both ears. It
causes no pain, in this mild character, and but little hardness
of hearing; it brings about rather a stuffed feeling in the ears,
with a slightly altered timbre of objective sounds. There is
usually some tinnitus, though a slight chronic tinnitus may
cease upon the occurrence of a mild tubal catarrh. The patient's
voice may be subjectively altered; though this is rare in light
cases of catarrh of the ear. The membrana tympani may not
even lose its lustre, though its vessels may appear slightly con-
gested, and it may assume, if it is ordinarily transparent, a
pinkish hue from the shining through of the congested tympanic
vessels.

This form of catarrhal congestion of the middle ear rarely
troubles the patient, and therefore receives very little attention.
It may disappear as rapidly as it came, in the course of a day,
without any treatment.

That form, however, characterized chiefly by pain, hardness
of hearing, and subjective noises in the ear, is not only more
annoying to the patient, but demands prompt treatment. It
comes on usually after exposure to cold; but it may be caused
by various diseases involving the mucous membrane of the nose,
mouth, throat, and naso-pharynx, as syphilis, various continued
fevers, and the exanthemata.

Acute catarrh is more likely to affect one ear than both, and
is apt to come on in an ear already affected by chronic catarrhal
disease.

Pain.—The pain is not as severe as that of purulent inflam-
mation of the middle ear, and this is perhaps the chief early
diagnostic point between the two diseases. The pain, usually
darting only from throat to ear, may become sharp and boring

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and not limited to the ear. It is then very apt to follow the course of the fifth and seventh cranial nerves, and in this phase is not unfrequently mistaken for neuralgia both by patient and physician.

It intermits during the day, growing worse at night, but never becomes as intense and unendurable as the pain of acute purulent otitis. It is often more a sensation of great fulness than true pain. Fever is rarely present, and the cerebral symptoms are by no means grave; unless of course the aural disease accompanies or is caused by a febrile disease.

The pain is caused primarily by the inflammation of the mucous membrane, but it is aggravated and kept up by the results of the inflammation, i. e. by the swelling of the mucous membrane and by the increased amount of secretion.

The first acts by diminishing the size of the cavity of the middle ear and closing the Eustachian tube, by which means the air is excluded from the tympanic cavity, and the products of inflammation cause pain by directly pressing on the inflamed mucous lining of the tympanum and upon the membrana tympani.

Vacuum formed in the Tympanum.—If the faucial mouth of the Eustachian tube becomes swollen and blocked up with mucus, the tympanic cavity is deprived of its proper ventilation, the air which was in the cavity at the beginning of the tubal catarrh becomes absorbed, and, since no fresh supply of air can get through the swollen tube, a vacuum is formed in the cavity of the drum. This condition tends to produce pain; in children, it is often the only cause of pain in acute catarrh of the tube and tympanum, for, the external atmospheric pressure remaining constant, the membrana tympani is forced inward, carrying with it the chain of ossicles. A continuance of the vacuum may lead not only to a great extravasation from the tympanic vessels, but even to their rupture. Hence, it is not uncommon to find true ecchymosis on the membrana tympani, after the Eustachian tube has been closed for some hours, in a case of acute aural catarrh. In some such way we may account for the rare cases of so-called otitis media hemorrhagica, to be referred to hereafter.

Pain increased by talking, coughing, sneezing, and eructation.—This is a prominent feature of acute aural catarrh, in which the

faucial mouth of the Eustachian tube is always affected. It is due, partly, to the muscular movements beneath the inflamed mucous membrane, and also to the direct effects of the forcibly expired air upon the inflamed lining of the tube and tympanum, before secretion has taken place. According to investigations of Lucæ,[1] it seems highly probable that, at each expiration, the air in the naso-pharyngeal space is condensed, and hence pushed into the more or less normally patulous Eustachian tube.

No one symptom in acute aural catarrh is so universally spoken of by patients as the painful effect of eructation. It is very common, indeed, for this to be complained of as the only symptom in cases of congestion in either a previously perfectly healthy tube, or during an intercurrent acute congestion in a chronic aural catarrh. Patients under treatment for the latter will, upon changes in the weather, complain of the above symptoms.

As those affected with chronic aural catarrh are also very apt to have a slight paresis of the velum, which prevents its being able to perfectly close the upper from the lower pharynx, it would seem that sudden eructations or any forcible expiration may be all the more likely to strike against the pharyngeal mouth of the Eustachian tube, and, in some cases, even penetrate into the tympanic cavity.

Both Senac and Tissot[2] observed difficulty in swallowing in cases of ear-ache which the former attributed to sympathy (consensus) between the pharynx and the ear, but which the latter observes " is connected with a slight inflammation of certain of the muscles of deglutition." I have observed in my own case that when the faucial mouth of the Eustachian tube is slightly swollen, i. e. when, with a slight cold in the head, the tube does not become readily patulous on swallowing, a slight touch of the finger in the external auditory canal produces an intense tickling in the fauces high up behind the velum, and I am forced to cough. This peculiar sensibility does not exist in my ear when the Eustachian tube is unaffected, but probably every observer knows, as the author does, of many

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[1] Virchow's Archiv, Band lxiv., Zur Function der Tuba Eustachii und des Gaumensegels.

[2] Traité des Nerfs et de leurs Maladies, Paris et Londres, 1780, p. 54.

persons in whom the gentlest touch of the finger upon the mouth of the auditory canal will almost always bring about this peculiar dry cough, called ear-cough. (See p. 326.) I have observed that children whose ears are perfectly healthy, as well as those whose ears are more or less diseased, are especially susceptible to this reflex cough. I have seen infants exhibit marked ear-cough upon their mothers' most gently touching the concha or brushing some small object from the vicinity of the mouth of the external auditory canal. But even those of any age in whom this reflex cough is found, are not always equally sensitive, for it is more easily produced at one time that at another. It is, on the whole, most likely to attend some morbid condition of the ear, and I have seen it often in cases of acute catarrh of all grades.

Hardness of Hearing.—The hardness of hearing is caused chiefly by the swelling of the mucous membrane and the collection of mucus and extravasated serum in the tympanic cavity. These alterations in the tympanum interfere with the vibratory motions of the auditory ossicles, the former by a direct stiffening of all their joints, and the second by loading not only the ossicles but the fenestræ. Hence, hardness of hearing is most marked after secretion has taken place. At the onset of the inflammation the hearing may be morbidly acute. A secondary implication of the labyrinth by an extension of inflammation or congestion from the tympanum very probably often occurs, and tends to further impair the hearing. Throughout this disease the resonance of the patient's voice is liable to annoying subjective alterations, most probably due to the altered condition of the Eustachian tube.

Tinnitus Aurium.—This is one of the chief symptoms of acute aural catarrh. It is caused principally by the altered circulation in the tympanum, and seems to become more aggravated as the inflammation advances. It resembles, very often, painfully high musical notes, and is one of the most distressing symptoms, being complained of almost as much as the pain. I have observed that the tinnitus is of the constant variety, *i. e.*, unaffected by the pulsation, in simple catarrh with an increased amount of mucus; when the inflammation becomes more severe, and purulent symptoms supervene, then, in some cases, the tinnitus becomes interrupted by the pulsations, and each heart-beat is felt

in the ear most painfully. The tinnitus of acute catarrh is referred rather to the ear than the entire head; the latter variety seems to indicate severer inflammation. The more musical variety of tinnitus aurium is probably due to a secondary implication of the cochlea in the congestion. The subjective noises may be entirely unmusical in their sound, resembling merely a crackling of mucus or the bursting of bubbles of a tenacious substance. This latter kind of noise in the ear would seem to be not very difficult of explanation, and should be referred to the movements in the mucus in the middle ear. It is, of course, characteristic of a late stage.

It may, therefore, be concluded, until a better explanation can be given, that tinnitus aurium, and in fact all forms of subjective noises in the ears, are due to what are best termed, in short, *morbid vibrations* originating in the various parts of the organ of hearing, *i. e.*, they have truly an *objective* existence in the *subject*. That a morbid circulation of the blood, let us say a too rapid flow of it, through the temporal artery may cause tinnitus aurium, I know by personal experience, and I also am fully aware that such a form of tinnitus may be hushed by pressure over that artery just in front of the tragus.

A distinguished professor of the University of Pennsylvania has told me that while he was a resident physician in the Pennsylvania Hospital, he was greatly annoyed by tinnitus in both ears, which he could always relieve by gentle pressure over the carotids. Such facts would tend to show that the blood may throw the vessels of the ear into such morbid vibrations that the latter are interpreted by the ear as sounds. If sound is motion, what can be more reasonable than such an explanation?

Tinnitus aurium, in general, may be explained by the " vascular theory" of Theobald.[1] At the outset in this theory a subjective sensation is to be regarded as having no imaginary but a real existence, and therefore tinnitus aurium has a real existence, being due to morbid vibrations produced in the vessels of the internal ear and then communicated to the nerve. Two modes whereby vibrations of the vessels of the labyrinth may be

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[1] Tinnitus Aurium, a consideration of the causes upon which it depends and an attempt to explain its production in accordance with physical principles, Samuel Theobald, M.D., Baltimore, 1875.

enabled to produce a sensible impression upon the auditory nerve
are suggested by Dr. Theobald, viz.: 1. The amplitude of the
vibrations may be increased; 2. The vibrations remaining un-
altered, their effect upon the nerve may be magnified, either by
reflection and concentration or by resonance.

The first condition may be said to exist whenever an undue
amount of friction attends the movements of the blood. "This
will happen when the normal relationship between the intra-
vascular and the intra-labyrinthine pressure is disturbed, or
when, in any other way, the natural and easy flow of the blood
is perturbed, as, for instance, in hyperæmia or anæmia of the
labyrinth vessels, increased or diminished intra-labyrinthine
tension, partial compression or obstruction of the trunks of the
vessels by inflammatory or other causes, and finally, when the
constitution of the blood itself is altered, as in spanæmia or
chlorosis. The tinnitus which is known to occur in increased
labyrinthine pressure is attributed "to the accompanying vas-
cular disturbance, rather than regarded as the expression of an
irritation of the nerve, the immediate result of compression."

Tinnitus aurium occurring in diseases of the middle and
external ear, unaccompanied by pressure in the labyrinth, may
be referred to the defect in the sound-conducting apparatus, as
suggested by Theobald. Whenever waves of sound cannot
obtain normal admission from without, to the percipient parts
of the ear, tinnitus aurium may also be referred to the same
kind of obstruction, "for those conditions of the sound-con-
ducting apparatus which prohibit the entrance of sounds from
without will also prevent their escape from within, and this, as
we well know, will magnify their effect upon the nerve, or, as
we would say, increases their loudness." The well-known fact
that tinnitus aurium is not often complained of when a perfora-
tion in the membrana tympani exists, is explained by Theobald
as due to the ready escape thus offered to the vibrations occur-
ring in the ear.

The probability of the origin of tinnitus in this way is in-
creased by the fact that just the notes of high pitch which these
delicate vascular vibrations would make, would correspond to
the generally high quality of subjective noises in the ear.

Dr. Blake[1] has shown that notes of tuning-forks which give

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[1] Transactions American Otological Society, vol. i. p. 438.

an extremely high number of vibrations per second are heard much more easily when the membrana tympani is perforated, that is, they gain access to the auditory nerve more readily. This being undoubtedly the case, as shown by Blake's experiments, Dr. Theobald is apparently fully justified in his theory as to the ready escape of high tones originating in the vascular movements of the labyrinth, which might be interpreted by the ear as tinnitus, did they not readily escape through the perforation in the membrana tympani.

Why the ordinary normal vascular movements in the labyrinth are not productive of tinnitus aurium is not yet explained, excepting on the supposition that a normal ear permits of the escape of all vibrations produced by ordinary vascular movements in the ear, without perceiving them as sound.

The optic nerve, less the retina, is entirely insensible to light, and it is highly probable that the auditory nerve, less its terminal filaments in the labyrinth, is equally insensible to sound ; therefore Dr. Theobald raises the very significant question, " Since these two nerves are respectively incapable of responding to the stimulus of light itself or sound itself, is it at all likely that such sensations could be excited in them by an other mode of stimulation ?"

He therefore asserts his conviction that tinnitus is invariably due to an excitation of the percipient elements of the auditory nerve, and he disbelieves that it can exist as the result of direct irritation of the nerve-trunk, and also questions the existence of what may be termed cerebral tinnitus, i. e. tinnitus originating in the brain independently of the auditory nerve. But he admits that aural hallucinations may and do originate in this manner as the result of certain cerebral disorders ; but these are different in character from true tinnitus, and should not be confounded with it.

That motions sufficient to produce sound are constantly going on in the ear, which, however, the latter fails to hear, in the normal correlation of forces obtaining in the healthy organ, is proven by gently stopping a well ear, whereupon tinnitus of varied pitch may be perceived.

This, as has already been said, is due to the altered resonance and reflection brought about in the ear by the stoppage of the meatus with the finger ; for that which prevents sounds, i. e.

vibrations, from entering the ear will also prevent the escape of those originating in the ear, and thus the ear hears the so-called subjective sounds.

Double Hearing or Subjective Echo-like Sensation; Paracusis Duplicata; Subjective Alteration in Pitch.—Double hearing, or a subjective echo-like perception of tones or words, has been noted by several authors as connected with acute catarrh of the middle ear.

Generally the latter part of the word is thus perceived; it seems to be higher in pitch, as I can testify by observation of this phenomenon in my right ear. During a slight catarrhal closure of the Eustachian tube without pain, I heard a disagreeable echo of the last syllables of words in my right ear. The tones of the syllables thus perceived were certainly higher in pitch than the word as spoken to me. How great this sharping was, I cannot state. The notes of the piano did not seem to me to be thus sharped, nor were they subjectively echoed in their true pitch.

In some cases both words and musical notes are perceived in this peculiar echo-like way, without alteration in pitch; this is more likely to be the case with words than with musical tones. The latter are usually sharped a half tone or more.

Some of the earliest accounts of this phenomenon are those of Sauvages, Itard, and Von Gumpert;[1] the same symptom has been noted by Von Troeltsch and Politzer. The cases of Sauvages and Itard were observed in patients suffering with catarrh of the middle ear. Von Gumpert observed the phenomenon on himself. The subjective difference in the note varied between the third, the fourth, and the octave. He also perceived the echo-like ending of words. The peculiarity lasted for a week.

Von Wittich,[2] too, observed most critically a similar alteration in his own hearing, four weeks after an inflammation in his ear. " The notes of a tuning-fork appeared exactly a half-tone higher in the diseased ear than in the well one. The same was perceived respecting notes of the middle scale, either when whistled or

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[1] Quoted by Bressler: Die Krankheiten des Kopfes und der Sinnesorgane, Berlin, 1840, Bd. ii. p. 375. See Moos and Gruber.
[2] Königsberg Med. Jahrbücher, Bd. iii., 1861.

struck on the piano. They were heard *double*, the difference be-
tween the two sides being a half tone."

" This phenomenon remained unaltered, both when the ex-
ternal auditory canal on the affected side was filled with water
or cotton-wool, and when by inflation the membrana tympani was
made to change its tension. Apparently, a somewhat different
phenomenon presented itself when a vibrating tuning-fork was
placed on the teeth, for the natural tone was heard gradually to
die away into the next half tone higher."

In the latter instance there was apparently a double hearing,
or an after-hearing of the true note sharped, in the diseased ear.

When the fork was placed on the vertex, the tone appeared
higher the nearer it was to the affected ear. Two forks, one of
which was half a tone higher than the other, were heard as the
same note, when the higher was held before the well ear and the
lower before the diseased ear.

Sir Everard Home[1] has related the case of an eminent music
teacher, who, after catching cold, perceived, in addition to con-
fusion of sounds in his ears, that the pitch of one ear was half
a note lower than that of the other; and also that the percep-
tion of a simple sound did not reach both ears at the same time,
but seemed as two distinct sounds following each other in quick
succession, the latter being the lower and weaker.

This phenomenon was considered by Home to be due to
defective action in the muscular structures governing the ten-
sion of the membrana tympani, although it is evident he
was entirely unacquainted with these structures, since he de-
scribed as he thought a radiate muscle lying in the drum-head,
whereas no such structure exists as part of the layers of this
membrane. But that he has accurately described a case of
double hearing and subjective alterations in pitch, is beyond
doubt.

Prof. Moos[2] places this peculiarity among the longest known
affections of Corti's organ.

He relates two cases: one, that of a tenor singer who, for four-
teen days after a severe coryza, heard simultaneously the treble
of all the notes he sang. This was found to be due to catarrh
of the middle ear and some hardness of hearing on both sides.

[1] Philosophical Transactions, Royal Society of London, Part I. 1800.
[2] Klinik d. Ohrenheilkunde, pp. 319–320, 1866.

Catheterization and injections of sal ammoniac (gr. x to f℥j) entirely relieved the patient.

The same author gives an account of double hearing in a case of chronic catarrh of the middle ear. In this instance the phenomenon of double hearing came on after the patient used chloroform for relief from an attack of asthma. Immediately after the narcosis the hearing was worse, subjective noises of various descriptions were perceived, and the patient noticed that all notes from a′ up were heard double in both ears. Later the notes thus doubled were e″ and all notes from that point up the scale.

Could not these subjective phenomena of hearing be ascribed to the exacerbation of catarrh produced by the breathing of the chloroform, and secondarily to the congestion and altered tension in Corti's organ?

Prof. Gruber[1] has noted the phenomenon in two cases: in one case, that of a musician, a musical tone was heard a third higher. In some instances the after sound may be of the same pitch as the original note.

Among later accounts of this peculiar phenomenon, one given by Dr. H. Knapp[2] is of interest, and may be regarded as rare. The double hearing in this instance was observed in the case of a young man suffering from acute otitis media on the left side. The hearing for the watch was very much reduced; musical sounds were heard nearly normally, but the note of a tuning-fork placed on the glabella was heard about two notes higher in the affected ear than in the well ear.

Wittich and Knapp do not seem to use the word double as it is used by others; most writers seem to mean that a note is heard double when it is perceived as it were twice by the same ear—first in its true pitch, then, in an echo-like way, sharped. But, judging simply from the context in the cases just named, it would appear that the note was heard by the diseased ear only sharped, while the true pitch was perceived by the well ear. In this sense the original note was heard double.

Perhaps this phenomenon, double hearing, would be noted more frequently if the patients were generally educated in

[1] Op. cit., p. 626.
[2] Transactions American Otological Society, 1869, p. 21.

music, for it is worthy of note that in the cases recorded the sufferers were musical.

CASE I. The first instance of double hearing, or, as I prefer to call it, subjective alteration of pitch, which I observed was in a young Austrian officer of good musical education, an amateur performer on the violin. During an acute otitis media on the left side, he noticed that in tuning his violin the note appeared a third higher in the affected than in the normal ear. This condition lasted for several days, but disappeared with the acute disease of the ear.

In this case the hearing could be called double in the sense that the normal ear heard the true note and the diseased ear another, viz., one apparently higher than the original note, producing subjective confusion.

CASE II. In this case the subjective alteration in pitch occurred in both ears. During a successful treatment for chronic purulent disease of both ears, the patient, a young woman of 23, music teacher, suffered from a slight intercurrent acute otitis media on both sides. All sounds became disagreeable, and she especially noted and complained of a sharping of all musical tones of the voice of others in singing and of the notes on the piano. This, however, disappeared in a week, and the purulent disease was finally cured. The hearing in this case became almost normal after the disappearance of the suppurative disease of the middle ears.

In this second case it could hardly be said the patient suffered from double hearing, for she heard a similar subjective sharping of piano-notes in both ears. This she knew to be the case, not by discord but by her knowledge of music, for she knew, when she struck a given note on the piano, that the note her ears perceived in their diseased state was sharper than the note she heard when the same key was struck by her in health.

Intra-Tympanic Pressure during Phonation.—Under normal conditions, phonation produces variations in pressure both in the mouth and naso-pharyngeal space. Experiments of Dr. C. J. Blake[1] show that this pressure is sufficient to be communicated to the tympanic cavity through the Eustachian tube. This pres-

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[1] Intra-tympanic Pressure during Phonation, Trans. Amer. Otol. Soc., vol. ii. p. 75, 1875.

sure may become painful in some cases of disease of the middle
ear. In such instances the patient may voluntarily avoid pro-
nouncing the nasal consonant sounds m, n, and ng, since the
pressure in the tympanum, brought about by their phonation,
is painful.

The sensations produced by their pronunciation has been de-
scribed as a disagreeable cracking and bursting sound, least so
with m; most so with ng. In a case of this kind observed by
Dr. Blake, a cicatrix in the membrana tympani was seen to
make vibrations with each of the above consonant sounds; least
with m, a larger one with n, and " with ng a double excursion
was observed, the membrane only partially resuming its original
position between the two movements." All of these unpleasant
symptoms were relieved by excision of a portion of the flaccid
cicatrix. A round opening was thus made, the symptoms above
named disappeared, and the patient articulated normally. Dr.
Blake also found that a manometric column of water (diam. 1
mm.) connected with the meatus, when m. was pronounced, rose
and fell $\frac{1}{2}$ mm.; with n, nearly 1 mm.; and with ng, a double
rise and fall of nearly the same degree was observed.

*Recurrence, every year for fourteen years, of a Peculiar Subjective
Noise and Altered Resonance of Voice, in the Left Ear; Tempo-
rarily relieved by Pressure on the Auricle and Meatus.*—Septem-
ber 9, 1873, Mrs. C., 35 years old, living in affluence, states that
for fourteen years she has experienced an altered resonance of
her voice and some buzzing noise in the left ear, which come on
together in June, with the warm weather, and last until Sep-
tember. She also makes the strange statement that these sub-
jective alterations become appparent to her toward midday and
last until about bedtime. She can always gain relief for a few
moments by pressing and pushing the auricle and meatus on
the affected side, but as soon thereafter as she swallows, the
altered resonance returns. The hearing remains unaltered and
certainly appears perfect on testing. The voices of others are
never changed in quality as her own is. She says she has in
winter, catarrh of the throat, at which time there is more or less
soreness confined to the Eustachian region on the side where
these peculiar alterations occur in the summer season.

In winter, however, these subjective alterations have never

occurred. Examination revealed a somewhat granular throat, without hypersecretion.

The membrana tympani was normal in every respect, unless an exception be found in its being a little more indrawn than its fellow. The tuning-fork placed on the top of the head was heard equally well in both ears. The Eustachian tubes were readily pervious to air from Politzer's bag. If the statements concerning these peculiar subjective symptoms in the left ear are to be credited (the woman was thoroughly intelligent and truthful), there are several points of great interest which earnestly demand some explanation. 1. The occurrence of these peculiar symptoms in summer time only. 2. Their coming on towards midday and passing off towards bedtime, i. e. about 9–10 P. M. 3. The temporary relief gained by pressing on the auricle and in the meatus; and 4. Their instantaneous return on swallowing.

Naturally the mind connects their causation with summer and its heat, which idea is only strengthened by the statement that they grew worse as the day grew warmer, and disappeared as the sun went down and the temperature fell.

The chief cause of this subjective alteration in the ear must be sought in the condition of the Eustachian tube.

It is not uncommon to find the nasal mucous membrane subject to an irritability from the heat of summer; it, therefore, seems fair to presume that the same irritability—a kind of erectility— may exist around the faucial end of the Eustachian tube. Let us suppose then that the heat of summer caused in this case a swelling in the tube in a manner suggested above; at the same time, it expanded the air locked up in the tympanum by the closure at the mouth of the Eustachian tube.

The expansion of the air contained in the tympanum forced the membrana tympani outward, and unlocked the malleo-incudal joint. This disturbed the equilibrium of these parts and brought about very much such an altered resonance as any one experiences after blowing the nose during an ordinary nasal and faucial catarrh.

This pushing outward of the membrana tympani was sustained by the expanded air of the tympanum until the patient pushed the auricle and pressed the finger-end into the meatus. Then the column of air in the external auditory canal, being condensed by the pressure from the finger-tip, forced the mem-

brana tympani inward. The latter, in turn, pushed some of the expanded air of the drum-cavity out through the slightly swollen Eustachian tube, and resumed, with the ossicula, a position of equilibrium, and then vibrated normally until an act of swallowing occurred. Then the altered resonance returned.

The return of the peculiar subjective resonance after the act of swallowing can be explained thus: The first effect of swallowing is to open the Eustachian tube and to force air in the drum-cavity, but in the normal, loosely closing, or closed tube (Lucæ), more than the requisite amount of air recoils, and the equilibrium is maintained in the tympanum. In this case the tube was enough swollen to interfere with the recoil of a surplus of air which it was obliged to permit to enter the drum-cavity at the relatively powerful act of swallowing. According to Lucæ, so powerful is this act, and so great is the amount of air forced into the tympanum by it, that the first effect in the latter cavity is one of condensation. In this case the tube was not so much swollen as not to permit the usual large amount of air to enter the tympanum at swallowing, but it was enough irritated and narrowed by the effects of heat to interfere with the ready recoil of the surplus of air forced into the drum-cavity by swallowing; hence too much air remained in the tympanum, the equilibrium remained disturbed, and the peculiar resonance became once more apparent, until the finger forced the membrana tympani back to a normal position.

Acute Aural Catarrh in Infants and Young Children.—Since this disease constitutes the so-called ear-ache in little children, it will be well to bestow more than ordinary comment on its occurrence in infants and very young children. Unfortunately it is a disease too commonly overlooked in them, partly on account of their inability to locate their pain and communicate their feelings to others, and also on account of the difficulty of examining young and suffering infants. Hence the disease may escape proper treatment and lead finally to permanent injury of hearing, and even to results fatal to life if allowed to pass into the purulent form of tympanic inflammation. This disease of the ear is apt to come on with catarrh of the air-passages, teething, whooping-cough, and the exanthemata. Its most common occurrence is during a cold. If in an infant, the little victim will suddenly cry out most piteously, at first only with every

severer twinge of the increasing pain, but at last it will utter a quick succession of piteous and peculiar shrieks. This cry has been said to resemble that occurring in acute bowel-disease, and has often been mistaken for that in infants. But the continuance of the pain, despite the treatment directed to the bowels, will soon show the careful observer that the disease is not in the intestines. The infant will refuse all nourishment, the breast or the bottle is pushed away, and if the nurse now endeavors to dandle the little sufferer, each movement will cause it to shriek more loudly, and convulsions may supervene. The cries may be so dreadful that isolation of the patient in a remote part of the house becomes necessary in order not to alarm his relatives and neighbors. Such severe forms usually terminate in suppuration.

Very frequently, attacks of ear-ache from acute aural catarrh come on only at night, for several nights in succession, but in the intervening daytime the little patient plays about as usual. If the ear is examined in such cases, the membrana tympani will be found greatly drawn in and lustreless, looking like ground glass, or a polished steel surface just breathed upon. The manubrium of the malleus in such cases is so much retracted and foreshortened, that it will appear far up and behind in the posterior superior quadrant of the drum-head.

These cases are primarily and emphatically *tubal catarrh* with more or less hyperæmic swelling of the lining mucous membrane of the tympanic cavity.

The pain is aggravated at night, especially by the recumbent position, which, of course, increases the congestion and swelling, both in the tube and tympanum. Thus, the vacuum already alluded to is made greater, and the external air presses with greater force on the outer surface of the membrana tympani, forcing the latter inward, and with it the chain of ossicles. The freedom from pain in the daytime is due to a partial subsidence of swelling in the tube and tympanum, and consequently to less of a forcing inward of the membrana tympani and the ossicles. A want of air in the tympanic cavity is, therefore, one of the chief causes of pain in these cases of acute catarrh of the ear ; and hence, sneezing, blowing the nose, or an artificial inflation of the tympanum will usually cause a cessation of the pain, by overcoming the vacuum in the tympanic cavity and relieving the undue tension of the drum-membrane.

In very young children, a high degree of deafness may be present from merely a persistent simple catarrhal process in the Eustachian tube. If the latter is opened, usually by one good inflation with Politzer's air-bag, the hearing is instantly greatly improved, and a few repetitions, every other day, of this manipulation will effect an entire cure of the case.[1] But such cases, I believe, are rarely recognized soon enough for beneficial treatment. Yet, I have seen enough of them to lead me to conclude that many cases of chronic deafness, in those just arriving at the age of puberty, are attributable solely to neglect of simple catarrh of the tube four or five years previously. In such cases the closure of the Eustachian tube, especially if it be on only one side, is either not noticed by the patient or his friends, or, if noticed, is neglected, in the hope that the child will outgrow the trouble: and it appears that it sometimes does. Usually, however, the tube being closed for a long time and the tympanum deprived of air, the latter loses, often irretrievably, its function, just as an air-sac in the lung would, beyond a stopped-up bronchial tubule.

Acute aural catarrh in larger children is usually the result of undue exposure to dampness and cold while at play in winter sports. I have seen this intense suffering come on after the child's companions had "washed" its ears with snow.

Although these attacks of acute catarrhal inflammation of the middle ear, from imprudent exposure to cold, are both common and painful, they are not usually so likely to become chronic, and thus permanently injure the hearing, as those forms of aural inflammation brought on by the exanthemata. The latter usually lead to purulent inflammation and spontaneous rupture of the membrana tympani, but acute catarrh may run a painful course, without producing spontaneous rupture of the drum-membrane. In fact, this tendency to produce a spontaneous rupture of the drum-head, or not, is one of the distinguishing marks between acute purulent and acute catarrhal inflammation of the middle ear.

The large majority of all cases of chronic purulent inflammation of the middle ear, are unhesitatingly attributed by the

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[1] Seltener Fall eines einfachen chronischen Mittelohrkatarrhs. Dr. E. Politzer, of Pesth, Archiv f. Ohrenheilkunde N. F., Band i. p. 48.

patients to the exanthemata or to some of the continued fevers. If the purulent discharge is said to be the result of earache from cold, it is usually found to date back to earliest infancy. Another equally striking fact is that chronic aural catarrh—i. e. oft-returning and slowly increasing hardness of hearing, the so-called progressive hardness of hearing (Weber-Liel), or proliferous inflammation (Roosa)—is almost invariably attributed to, or at least said to be aggravated by, cold in the head. It may be that inflammation of the middle ear, caused by cold in the head or acute inflammation of the air-passages, is of a sthenic type, while that produced by blood-poisoning of any kind, exanthemata, continued fevers, syphilis, etc., is of a decidedly asthenic type, tending to destruction of tissue.

Objective Symptoms in Acute Catarrh of the Middle Ear.—If the membrana tympani can be examined in the first stages of this disease, there will be noted, first, a slight congestion about the periphery of the membrane, with a somewhat greater amount in the membrana flaccida and in the vessels lying over the handle of the malleus. The color of the membrana tympani, in general, will not be much altered at first, but its lustre may be slightly dimmed, and the pyramid of light will become faint or fade entirely. In many cases, even in those with considerable accumulation of mucus in the tympanum, the membrana tympani will not lose its contour, as it does in the purulent form of otitis media. A marked objective symptom, however, is the retraction of the membrana tympani.

Retraction of Membrana Tympani.—The retraction of the membrana tympani may be so great in these cases, on account of exhaustion of the air from the tympanic cavity, that mucus in quite large quantities may be present without causing any bulging of the drum-head. In such cases, however, unless the drum-head is very thick, the mucus can be seen through the delicate membrane; the color of the latter will then be influenced by that of the mucus in the tympanic cavity, and the surface of the membrana tympani may finally be made to bulge, either in spots, by lumps of mucus, or regularly at some one segment, mostly the hinder, by a more homogeneous kind of mucus.

Spontaneous Rupture of the Membrana Tympani.—Spontaneous rupture of the membrana tympani is rare in simple acute

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catarrhal inflammation of the middle ear. I consider this the
chief diagnostic point between this disease and acute purulent
inflammation of the middle ear, to which, I grant, the acute
catarrh is only too likely to lead. But since, as a matter of
fact, we rarely find purely mucous products breaking down the
membrana tympani and discharging themselves through the
opening thus made, while we constantly find pus escaping in
this manner, I am forced to conclude that acute catarrhal
inflammation leads rather to a thickening of tissue than to
the more destructive disease—acute purulent inflammation of
the mucous lining of the middle ear. In the latter instance we
invariably find purulent discharge escaping from one or more
spontaneous ruptures in the membrana tympani. The same
view was entertained by Rau,[1] who states that the results of
inflammation, comprehended " under perforation of the mem-
brana tympani, destruction of the ossicles of hearing, caries of
the mastoid," etc., do not follow acute catarrhal inflammation
of the ear, but are results of the acute purulent form of aural
disease.

I observed, not long since, in a medical man, 60 years old,
just recovering from pneumonia, an apparent exception to what
seems the rule, that pure mucus is never found escaping through
a spontaneous opening in the membrana tympani. A little pain,
with considerable dulness of hearing, were the first symptoms.
These were noted by the patient some days before the membrana
tympani was examined. I found the membrana tympani uni-
formly pinkish and thick in appearance, lustreless and bulging
in its entire posterior half; the position of the malleus plainly
visible. Paracentesis of the drum-membrane was proposed by
me, but not performed, at request of patient; and that night and
the next morning jelly-like, transparent mucus, resembling
thick white of egg, came from the tympanum through a sponta-
neous opening in the drum-membrane. This perforation healed
in a day. Although this case was complicated by a deep-seated
abscess of the cellular tissue over the mastoid portion, the
hearing was fully restored. The membrana tympani now shows
a small, grayish spot in the posterior segment where the open-
ing occurred.

[1] Ohrenheilkunde, sec. 195.

In addition to the chief symptoms, fulness and pain in the ear, with hardness of hearing and tinnitus aurium, we shall find, usually, in acute catarrh of the ear, general catarrhal symptoms of sore throat, cold in the head, cough and hoarseness, and some headache; but vertigo and fever are not common attendants of this disease. The latter symptoms are usually proportioned to the severity of the pain. As a rule, all the symptoms of acute aural catarrh will be found abating with the cessation of the general catarrhal symptoms, excepting, perhaps, the deafness, which may increase with the general increase of local secretion from the various parts of the mucous tract implicated in the general catarrh. The cause of this increase in the deafness is, of course, due to the mechanical obstruction in the Eustachian tube and tympanic cavity, brought about by the large amount of thick mucus retained in the middle ear, by the swelling of its mucous lining. The latter may be kept up by additional attacks of slight catarrhal swelling.

Course.—This affection may lead rapidly to purulent inflammation of the middle ear. It is not, however, the more violent form, either in children or adults, which leads to permanent deafness. The oft-recurring, slight attacks of fulness in the ears, with every cold in the head, are most likely to lead to a chronic catarrhal swelling and deafness. Such cases finally cause an accumulation of inspissated mucus in the tympanic cavity, according to some observers (Hinton). My experience would lead me to believe that such accumulations are not as common in this country, with its drier climate, as they are in England, where, as is well known, the atmosphere is more moist. Be this as it may, respecting the accumulations of mucus, it is very sure that the oft-recurring stuffed feeling in the ears, with every cold in the head, usually leads to permanent changes in the hearing unless relieved by proper treatment.

Etiology.—Acute catarrh of the middle ear is most apt to occur in the spring and autumn, or in changeable weather in mid-winter, and is usually found whenever catarrh of the air-passages is prevalent. It is also caused by teething, whooping-cough, continued fevers, the exanthemata, and syphilis. In summer-time there are two great causes for its occurrence, viz.,

cold bathing and diving, and sitting in a draught of air to cool the heated body. In the first instance, the exposure of the ear to breakers or to the cold water in diving is the cause of the inflammation. This is easily understood when one reflects that the membrana tympani is so thin that its mucous surface is practically brought into direct contact with the cold water whenever the latter enters the external auditory canal, as in diving, or by any other incautious means. It would seem that in such cases the inflammation of the tympanic cavity is secondary to a myringitis produced by the cold water. In the second instance, when inflammation of the middle ear comes on after cooling off in a draught of air, it seems to be the result of a general constitutional disturbance due to the exposure of the heated cutaneous surface to cold air, and the result is similar to a chilling of the surface of the body in winter, when, as is well known, the aural disease is often joined to sore throat and coryza, all of which are due to the same atmospheric or telluric cause.

Many cases of catarrhal inflammation of the tympanic cavity may be said to be to a great extent mechanical in their origin. The catarrh of the Eustachian tube closes up that important communication between the tympanum and the fauces, causing a vacuum and a retention of mucus in the drum-cavity. Consequently an irritation is set up there, both by the want of air in the drum and a slow decomposition of the retained tympanic excretions. Hence many an acute catarrhal process in the tympanic cavity, accompanied even by pain, may be cut short by one or two good inflations by means of Politzer's air-bag. A great many cases of acute catarrh of the middle ear are produced by sudden exposure to the air after all forms of vapor baths. The heroic Turkish and Russian baths, so largely advertised, are constantly producing acute catarrh of the ear. The same evil result is often due to " cold packing" in water-cure establishments.

Acute catarrh of the middle ear is most frequently caused by cold bathing. In June, 1875, a gentleman 40 years old came to me complaining of pain and tinnitus in his right ear following a long swim of one hour and a half in the surf at Cape May. In swimming he had always presented his right shoulder, and consequently his right ear, to the brunt of the waves. This

occasioned no pain at the time, but shortly after leaving the water the above-named unpleasant symptoms set in, and continued with rather lessening severity for four days, after which I examined the ear. The membrane was shining and unaltered, excepting by a little congestion and the pinkish hue it obtained from the hyperæmic condition of the mucous membrane of the tympanic cavity. In this case it is seen that the mucous lining of the tympanum was chiefly affected by the effects of the cold water transmitted through the drum-head, which had escaped injury. As the man was in perfect health, and the weather mild, the congestion disappeared in a few days by resolution, and the organ of hearing remained unaffected. But such conditions of the ear, brought on by cold bathing, usually terminate less favorably.

In September of 1875, I had the opportunity of observing a case of acute inflammation of the membrana tympani and tympanum, occurring in a waiter, a mulatto 22 years old, after repeated baths in the surf at Long Branch. The patient was phthisical, and had suffered from chronic purulent discharge from one ear for years; he had also persevered in his bath for days after the acute symptoms had set in in the previously well ear. The heretofore uninflamed membrana tympani was greatly congested, but intact when I first examined it, ten days after the cold bath. There were pain, loud tinnitus, and slight deafness in the ear. A little bulging or interlamellar swelling had occurred in the middle of the posterior segment of the membrana tympani, which I incised, and a small amount of opaque serum came out. On the following day a small granulation appeared at the incised point, the only granulation I ever saw as the result of a paracentesis of the drum-head. There was no otorrhœa before nor after this. The patient, being very much debilitated after a summer's hard work, was ordered to take iron thrice daily, and to protect the meatus with cotton-wool, as the weather was growing cooler. The pain ceased, but the tinnitus continued, being always worse at night. The hearing began to improve, but the membrana tympani still remained congested, there being a delicate vascular tracery over its entire surface. I stopped all local treatment, gave continued doses of iron; the granulation at the point of incision flattened, and at last shrivelled and disappeared; then the mem-

brana tympani grew paler, and the ear recovered its function entirely in about six weeks from the onset of the inflammation.

Another case of ear-disease from sea-bathing with rather mystifying symptoms came under my observation on August 31, 1875. A merchant, 35 years old, after prolonged bathing and diving through the breakers at Cape May, experienced increasing pain with annoying tinnitus in the right ear. This he endured for three weeks, putting in hot oil now and then, according to the vague advice of a local physician. At the end of that time and at the expiration of his visit at the sea-side, the patient presented the following symptoms: Great pain and tenderness on pressure deep in the mastoid portion, with constant buzzing in the ear; the pain radiated forward toward the temple and backward to the occiput; all of which symptoms grew worse at evening, reaching their intensity at midnight, but growing a little more endurable towards daylight. The hearing was $\frac{0}{60}$ in. for the watch.

The examination of the membrana tympani showed it to be somewhat puffy, as though distended by an interlamellar or interstitial exudation; but the congestion was not marked. The former swollen condition would attract the eye of the observer much sooner than the redness. Paracentesis caused a drop or two of opaque serum to exude, apparently from the substance of the swollen membrana tympani; but inflation of the middle ear by the method of Valsalva forced no fluid from the cavity of the tympanum. The air whistled through the perforated drum-head most freely, thus excluding any stoppage in the Eustachian tube.

The operation of paracentesis and inflation gave no relief to the pain, tinnitus, and hardness of hearing. I learned the next day that the patient had passed another dreadful night.

The membrana tympani was found to have healed, and the symptoms of congestion in it remained about as before the paracentesis.

The mastoid symptoms, pain, and tenderness increased, the patient's pulse was 100, and he had fever and loss of appetite, with general malaise and muscular weakness; but his intellect remained perfectly clear, though the signs of mastoid disease appeared to be grave. The bowels were freely opened by a

saline purgative, and the mastoid portion and ear freely leeched, two leeches being placed in front of the ear and two behind it. This giving only slight temporary relief, I advised an incision (Wilde's) down to the bone of the mastoid portion, but this was rejected by the patient at the urgent request of his family.

The case then passed from my notice, through some misunderstanding of messages; but in a few days, as I learned months after my last visit to the patient, all pain ceased, and the hearing gradually returned with the return of general strength to the sufferer, in the course of a month. The hearing, as far as I can learn, has never been as good, however, as it was before the attack.

The only possible explanation of the favorable issue of this severe and at one time apparently life-threatening attack, must be sought in a resolution of an intense hyperæmia of the periosteum of the mastoid region, consequent upon imprudent sea-bathing, the latter having also produced an inflammation of the membrana tympani, as seen by the discharge from the incision made in the membrane at the first visit.

Earache from Teething.—Earache occurs very often in teething; so frequently is it an attendant of this period of childhood that I have known mothers to prophesy with accuracy the coming through of a new tooth, on account of the sudden attack of earache. The vast majority of these cases never pass beyond the simple catarrhal form. This peculiar connection between teething and earache was also noted by Rau.[1]

In some instances we may find that the catarrhal inflammation has passed into the acute purulent form of tympanic inflammation, attended by perforation of the membrana tympani and discharge of puriform matter.

Earache in Whooping-Cough.—Whooping-cough is not an uncommon cause of acute catarrh of the middle ear; the perforation of the membrana tympani occurring in these cases is due to the mechanical force of the cough, not to merely spontaneous results from the catarrhal disease. Without doubt the inflammation in the tympanum weakens the lining of the cavity and favors its easy rupture by the force of the coughing.

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[1] Ohrenheilkunde, sec. 168.

Diagnosis.—The diagnosis of acute catarrh of the middle ear will be aided, chiefly, by the comparatively slight pain, the marked hardness of hearing, and the annoying hissing tinnitus, and, in a minor degree, by the presence of other catarrhal symptoms, such as sore throat, cough, etc., with little or no fever, nor any marked constitutional disturbance. It will also be noted that the pain is more easily overcome than the hardness of hearing, and that there is no tendency to a spontaneous rupture of the membrana tympani. When the patient inflates his ear, or when it is inflated artificially by the surgeon, loud mucous râles will be heard in it. These are audible in a marked degree to the patient, and easily heard by the surgeon's ear, when assisted by the ausculting tube.

Objectively, the diagnosis will be aided by careful inspection of the membrana tympani. The latter will be found to present the varying appearances already described, according to the stage of the disease. At times it may be noted with surprise, that the membrana tympani has not undergone great objective changes, notwithstanding the marked subjective symptoms in acute catarrh.

If the secretion of mucus has been large and consequently the deafness of a high degree, usually it will be seen that the membrana tympani is forced to bulge before the pressure of the retained tympanic mucus. Another important aid in diagnosis is the freedom of the auricle and auditory canal from inflammation. These may be handled without pain to the patient in acute aural catarrh, but if there is inflammation of any part of the external ear, ordinary examination with the speculum, which necessitates some traction on the auricle and meatus, will cause pain. This is often a means of finding out, in a case of asserted pain in the ear, where the seat of the disease is, or at least what division of the ear is probably most affected.

Prognosis.—The prognosis of acute catarrh of the middle ear is, on the whole, favorable. By careful observance of all the symptoms and prompt application of the treatment about to be detailed, usually the disease will terminate favorably. It should never be neglected, even in its mildest forms, since repeated slight attacks are very likely to lead at last to severe and perhaps permanent hardness of hearing.

Treatment.—The milder forms of congestion are to be treated by relieving the general catarrhal symptoms, and a thorough inflation of the tympanum. The *first* object is to be gained by opening the bowels, if necessary, and restoring the function of the skin, which is usually more or less disturbed. A mild diet must be observed, and spirituous drinks, smoking, chewing, and snuffing tobacco are to be sedulously avoided. The *second* object, inflating the tympanic cavity, is to be gained by using Politzer's air-bag, the Eustachian catheter, or Valsalva's method of inflation. By thus inflating the tympanum, the formation of a vacuum is prevented and the secretions are forced away from the ossicles and allowed to escape through the artificially opened Eustachian tube.

This is purely a rational treatment, and no novel one; in little children we may employ, as suggested by Mr. Hinton, of London, a piece of India-rubber tubing, through one end of which the surgeon may blow, while the other end is inserted into a nostril of the child. Air thus blown into the nostrils of children, will force open the Eustachian tube without any coöperation on the part of the patients; in fact, crying on their part will only *lift up* the palate, shut off the lower from the upper pharynx, and facilitate the passage of air into the tympanum.

If the child is tractable, prolonged phonation of the vowel a, or of the words hick, hack, hock, etc., according to the suggestions of Lucæ[1] and Gruber,[2] will aid in lifting the soft palate and in closing the naso-pharynx from the cavity of the mouth and throat. At the moment of, or during, this prolonged phonation, air may be forced into the tympana by Politzer's bag; if only one tympanum needs inflation, the one opposite to it may be firmly stopped with the finger during the operation of inflation, and thus, in some cases, it seems that more air is forced into the ear to be ventilated, because of the greater resistance offered by the voluntarily stopped ear to the column of air pressed into the naso-pharynx.

The treatment need not be actively antiphlogistic unless the pain and fever become severe. Should the pain grow intense, leeches must be applied in front of the tragus, as near as possible

[1] Virchow's Archiv, vol. xliv.
[2] Monatsschr. f. O., Nos. 10 and 11, 1875.

to the ear, and directly under the auricle. This is demanded in order to prevent suppuration.

Before leeches are applied, the mouth of the auditory canal should be stopped with cotton to prevent their crawling into the meatus. Such a mishap would cause the patient not only intense pain but most probably a severe external otitis. Hence, the advice sometimes given to deliberately apply the leech to the meatus is to be rejected. Even in the most favorable spot a leech-bite not unfrequently produces a circumscribed abscess.

Anodynes.—Anodynes should be given in doses sufficient to allay pain and produce sleep at night. A hop pillow will often prove very grateful in this malady.

In addition to the above means, warm and soothing gargles, and warm applications with the syringe or nasal douche, to the nose and naso-pharynx, together with rest in bed or in the room, will be found to hasten restoration to health and hearing.

Irrigation of the Naso-pharynx.—In most cases of acute aural catarrh, especially those in which the fauces, naso-pharynx, and Eustachian tube are inflamed, irrigation of these parts by warm fluids will be found grateful to the patient and very useful in the treatment of the disease.

Warm water, slightly impregnated with salt (tablespoonful to the pint) is most usually employed, and in acute cases is the best. Warm water containing chlorate of potash (3–5 gr. to f$\bar{3}$j) will also prove useful in some cases.

Fig. 66.
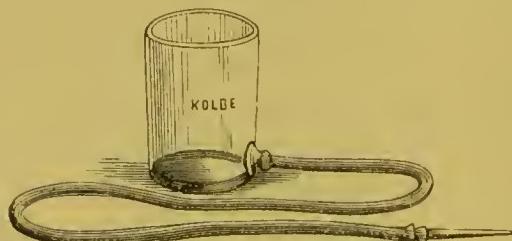
AURAL DOUCHE OF CLARKE.

The most convenient form of application of warm irrigation to the naso-pharynx is by means of Weber's (also called Thudicum's) nasal douche. Clarke's aural douche, and the ordinary syphon arrangement with a bowl of water and a piece of rubber tubing, will also well convey warm water applications to the naso-pharynx.

Irrigation of the nares and naso-pharynx may be accomplished by the syringe. But as the force with which the warm water is carried into these cavities by a syringe cannot always be regulated, great care must be exercised, to apply the fluids slowly and gently when obliged to use this means. It should be regarded as the last resort. Whatever has been urged against the nasal douche can most surely be urged against syringing the nares or the Eustachian tube. Yet I have been surprised to hear the former condemned by those who are willing to force a stream of fluid by means of a syringe directly through the Eustachian catheter into the Eustachian tube.

The use of nasal irrigation will be further considered when the treatment of chronic aural catarrh is reached.

It can but be repeated here that all forms of oils and fats are to be kept most carefully out of the ear, in this as in all other acute aural diseases. Sweet oil and other fats not only clog the ear and mask the disease, but they load the drum-membrane, increase the pain, and, as they are usually forgotten and left in the ear after the pain ceases, they become rancid and favor the growth of fungi. These in turn produce a painful and troublesome acute disease of the external, and even of the middle ear.

It would be well if it were remembered that most of the so-called remedies for earache would make a well ear painful if they were put into it.

Paracentesis of the Membrana Tympani.— If the collection of mucus in the tympanum becomes great, it will generally be best to incise the membrana tympani.

This should be done by means of the specially devised knife, at the posterior inferior quadrant, unless some other point protrudes very greatly. Some authorities advise waiting to incise the membrana tympani until spontaneous rupture is im-

Fig. 67.

PARACENTESIS KNIFE.

minent. Then, in order to have an opening in the most dependent portion of the drum-membrane, it is advisable to perforate it.

Absorption of the effusion may be brought about by a thorough ventilation of the tympanum, by means of Politzer's air-bag and the Eustachian catheter. Therefore, it may not be imperative to incise the membrana tympani in acute catarrh of the middle ear, unless the collection of mucus is great, the Eustachian tube stopped up, the pain severe, or spontaneous rupture is imminent.

However, to insure an entire removal of all products of inflammation in acute catarrh of the ear, especially if the disease occurs in a tympanum already affected and thickened by previous inflammatory processes, it will be found advantageous to perforate the membrana tympani.

Cases recover without this operation; but the incision of the membrane is so safe and simple that it is preferable to thus assure one's self that no mucus is left to harden in the tympanum and lay the foundation of future deafness.

CHAPTER II.

CHRONIC CATARRHAL INFLAMMATION.

THE onset of this disease is usually insidious. It may be preceded by numerous painful attacks of acute aural catarrh, but more frequently there is no history of precedent acute catarrh of the ear. Chronic catarrh of the middle ear is seen under two chief forms: (a) the secretory or moist, and (b) the asecretory or dry form. To these aspects of the chronic disease different names, and in some cases vastly different natures, have been assigned. But in both these chief forms it is usually found, on close examination, that a markedly catarrhal condition of adjacent and related mucous tissues either has preceded or attends the chronic aural disease. Even in those cases of chronic aural disease in which the nervous features are prominent, the latter usually are seen to be due to nutrient disturbances in the nerves of the middle ear, and possibly of the internal ear, induced by the antecedent aural catarrh. Indeed,

it seems that many cases of aural vertigo, under its numerous names, might be traced back to a chronic catarrhal disease of the middle ear.

Chronic aural catarrh, therefore, with its multitude of symptoms, has given rise to many different opinions as to its real nature and also to a very diverse nomenclature. This is due to the fact that the observation of the disease has usually begun at a more or less advanced stage of the affection, and but rarely continued until terminated by a careful study of the diseased tissues after death. Hence the number of names applied to this malady, as, "nervous deafness," "hypertrophic" and "proliferous inflammation," "sclerosis," and "chronic thickening of the mucous membrane of the tympanum," "anchylosis of the stapes," and "progressive hardness of hearing." They all possess the merit of designating at least marked characteristics of the malady to which they are applied. To the inquiring and observant student of aural disease, each of these terms will offer itself in many cases as the best descriptive name of the tedious complaint he finds before him. But no single one of them admits of universal application. "Chronic catarrh" seems to me to be indeed the only universally applicable name. It is comprehensive, and surely serves to denominate the essential nature of the disease.

SUBJECTIVE SYMPTOMS.

The earliest subjective symptoms of this disease are tinnitus aurium and a gradual diminution of the hearing. These symptoms appear usually only in one ear at a time, most commonly the left, and a varying period may elapse before the other ear is attacked. The onset of the subjective noise in the ear may be quite sudden; the time of its first occurrence can usually be stated accurately by the patient. This subjective buzzing, chirping, or hissing may appear on rising in the morning, during or after a severe cold in the head or after a depressing illness. The noise is not intense at first, but gradually becomes louder and more annoying, the hearing usually diminishing at the same pace. The statements of patients as to the quality and character of the subjective aural noise are extremely varying. The objective sounds to which they are likened are commonly taken

from the sounds to which the patient is most exposed; the mechanic seems to hear noises of machinery, the student the hissing or buzzing of a lamp, while the simmering of the teakettle is a universal similitude used to explain the quality of tinnitus aurium. In many cases a hyperæsthesia to objective sound seems to come on with the annoying subjective noises. I have known patients suffering with distressing subjective hissing in the ear and greatly reduced hearing, to complain bitterly of the intensely disagreeable effect on the diseased ear of the noises of the street, and of the blowing of the wind across the auricle while walking. This sensitiveness may persist for months. Sometimes patients seem to get used to the noise in the ear. When their attention is specially drawn to it they will state that they are aware of a singing in the ear but it is of no great moment to them. The singing in the ears is not very severe, nor does it grow louder in these cases. All subjective noises of the ear in this disease may be increased by fatigue, drinking spirits, smoking, and prolonged conversation. In some cases, after each meal the noise seems much louder. Some authorities[1] state that abnormal conditions of the genito-urinary apparatus tend to aggravate the tinnitus of chronic aural catarrh.

But in some cases, tinnitus aurium either never appears in the disease or only at a later stage, long after the hearing is much reduced.

These cases, being deprived of the warning as to the threatened failure of the function of the ear found in tinnitus aurium, are rarely made aware of the loss in hearing until it becomes very great. This is especially the case when one ear remains perfect. A failure of hearing in it, temporary or otherwise, is often the first occasion for noticing the defect in the other ear.

Or, a patient will come with the statement that while lying on the good ear in bed, accidentally it was discovered that some ordinary sound, such as the voice of a friend, the crying of a child, or the bell on the street-car, was not perceived by the free ear.

This has lead to domestic testing with a watch or a clock,

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[1] Weber-Liel, Progressive Schwerhörigkeit, p. 19.

and these are not perceived, or but imperfectly, in the ear which now for the first time is discovered to be faulty.

The coming on of this kind of deafness is so insidious that, in many cases, even among the most intelligent, there is no reliable history of the origin of the disease.

I have known children of physicians to be thus affected, but their fathers were not able to state when and how the disease probably began.

These cases, with no definite account of the beginning of deafness, seem in my experience to belong to a class with hereditary tendencies to chronic catarrh of the ear.

In the case of a physician's child, I found the father affected in one ear; in a young lawyer's, the father and uncles were similarly troubled. A young gentleman, growing markedly deaf in both ears, lately aggravated as he thought by shooting, stated that his family in some branches grew deaf, but he could not tell when the disease began to appear in him; he thought perhaps after undue exposure in the army ten years before. And such cases might be cited by scores.

Darts of pain are felt in some cases, every day or two; but this is not a very frequent symptom. If it occur it is only in the earlier stages. Most patients complain of a sense of fulness and discomfort in the ear, as the disease advances. If the secretion of mucus is considerable, more or less cracking is heard in the ear by the patient. After the ear cracks, it seems open for a little while, and the patient may hear better. But in a short time the sense of stoppage in the ear returns, and the hardness of hearing is again present.

Both pain and the sense of fulness are increased by changes in the weather during the winter season. In summer all such symptoms are very much less prominent.

A great sensitiveness of the ear may coexist with great deafness. Sounds which cannot be fully understood, *i. e.* words which are perceived only as sound, uttered very near an ear rendered entirely deaf by catarrh, will often produce pain in the ear.

With the tinnitus aurium, loss of hearing, and darting pain in some cases, disagreeable sensations are felt in the fauces, throat, and larynx. The character of these subjective conditions is variously described by the sufferers.

Most of them complain, however, of constriction, tickling, sense of fulness, and burning in the throat. All of these are aggravated by cold, any depressed state of health, or often by stimulating food. In some instances after an ordinary hearty meal, the throat will feel more or less burning, which is aggravated if the patient is obliged to talk in any prolonged way.

Very often the disagreeable feeling in the throat is described as that of a hair or foreign substance lying in the fauces, but which still clings there notwithstanding all efforts at swallowing. According to Weber-Liel,[1] this symptom is specially apt to be complained of by females. In a state of health all acts of swallowing can be felt, or heard, in the Eustachian tube and middle ear. But in these cases of chronic aural disease attended with pharyngeal symptoms, swallowing cannot be perceived in the affected ear by the patient; not even when the attention is drawn to the normal process by the physician.

Very few persons are aware that at each act of swallowing, they can perceive, if the Eustachian tube is in a normal state, a sensation of opening and crackling in the ear. This peculiar thud felt in the ears, at swallowing, is but the normal process of ventilation of the tympanic cavity. When the attention of one possessing good ears is drawn to this fact, it is then recognized, usually for the first time, so accustomed do all become to normal physiological processes.

Consequently any symptomatic change in this respect must be inquired for by the physician; for the patients never volunteer any information on this point, being, as already stated, ignorant of what a normal ear might perceive in swallowing.

Vertigo is sometimes felt in the later stages of this disease, but it cannot be considered a very common symptom according to my experience. When it is present as a symptom of chronic aural catarrh, it is paroxysmal in character. This characteristic alone would help to diagnose it from vertigo caused by cerebral disease. In the latter instance, the vertigo, if it occurs, is either constant or invariably produced by some particular act, like walking, and there is more or less permanent alteration in the gait. Vertigo caused by chronic aural disease is usually

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[1] Op. cit., p. 23.

connected with an increase in the subjective noises and an aggravation of the deafness. In such cases, any force which increases the pressure in the tympanic cavity is apt to bring on an attack of giddiness, as for example sudden swallowing, prolonged acts of deglutition, and powerful inflations of the tympanic cavity, whether by natural or artificial means. Changes in the weather, and consequent increases in the catarrhal symptoms, will often lend their aid in producing a greater tendency to aural vertigo. In most cases, by abatement of the catarrhal congestion, the vertigo will be lessened. In all such cases the Eustachian tube will be found to be at least temporarily narrowed, and the tympanum consequently imperfectly ventilated. The vertigo produced by inflation of a middle ear already diseased by chronic catarrh, and in which the membrana tympani is indrawn and more or less unyielding to forces intended to push it outward, is due to pressure on the foot-plate of the stirrup bone and upon the membrane of the round window. The latter membrane is highly susceptible to changes of atmospheric pressure in the tympanum, as recently shown by Weber-Liel.[1]

Since, in the almost sclerosed ear, the drum-head is both stiffened and held inward by the retraction of the tensor tympani muscle, air forced into the drum-cavity, instead of equalizing the pressure by carrying ahead of it the membrana tympani, which forms so large a part of the outer wall of the drum-cavity, is suddenly spent upon the more delicate coverings of the fenestræ in the inner wall of the tympanum. Pressure thus exerted on the labyrinth-fluid must produce not only a morbid oscillation and compression of the terminal filaments of the nerve of hearing, but also an alteration in the pressure of the cerebro-spinal fluid, for the labyrinthine fluid has been shown[2] to be in direct communication with the cerebro-spinal water.

It can be seen easily, therefore, how undue pressure in the labyrinth could be conveyed to the brain, and it seems also most rational to thus account for many cerebro-aural symptoms, rather than to seek for their elucidation in obscure affections of

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[1] Centralblatt für die Med. Wissenschaften, No. 2, 1876.

[2] Weber-Liel, Monatsschr. f. Ohrenh., Berlin, August, 1870, and Prof. Hasse, Anat. Studien, No. xix. p. 768.

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limited spots in the labyrinth, as for instance in the semicircular canals. Even could a specific lesion of these canals be more frequently demonstrated than it is, it is highly probable that all the symptoms of chronic aural catarrh can be found to have long preceded the symptoms of so-called Ménière's disease. As the distinctly catarrhal precede the vaguer labyrinthine symptoms in point of time, I believe they are more frequently causative than is generally supposed.

Hearing Better in a Noise.—Hearing better in a noise is very often a marked symptom of the later stages of chronic aural catarrh, when the condition of the tympanum has become dry and sclerotic, or when the thickening of the mucous membrane has become great in the moist form. This condition of the hearing, once supposed to be a mere fancy on the part of the patients, or at least due to the general elevation of the voice all are obliged to assume in a noise, has been shown to be real. Those presenting this symptom, Paracusis Willisiana, are found upon examination to hear the ticking of a watch somewhat better in a noise, for instance in a mill or a railway train, than in a quieter place. No entirely satisfactory explanation has ever yet been given for this.

Dr. A. H. Buck mentions,[1] but does not claim as an original idea, the following explanation for this peculiarity in hearing. "The pathological condition in the cases here under consideration is assumed to be one of rigidity, either of the annular membrane or ligament which holds the foot-plate of the stirrup in the fenestra ovalis, or of the secondary tympanic membrane covering the fenestra rotunda. Ordinary waves of sound, such, for instance, as are produced in ordinary conversation, are not of sufficient strength to overcome the rigidity of the annular ligament or of the secondary tympanic membrane; consequently the patient fails to hear the conversation. In the midst of loud noise, however, waves of sound are produced of sufficient strength to set the stirrup in motion in spite of the existing pathological obstacles. Once in vibration, this little ossicle, which might very properly be called the key to the auditory chamber, can perform with a certain degree of freedom the subordinate vibrations called into existence by the conversation

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[1] Report on the Progress of Otology, N. Y. Med. Record, June 5, 1875.

which is being carried on near by, vibrations which are neces-
sary to the act of hearing it. The louder tones open the door
for the entrance of the feebler ones." This can be most safely
considered a sign of great rigidity in the sound-conducting
parts of the tympanic cavity, and also one of unfavorable omen.

Hereditary Tendency.—The tendency to this disease is markedly
hereditary. Within a year I have been consulted by a woman
and her seven children for chronic aural catarrh. The woman
was about 40 years old; the oldest child was about 18 years old.
The disease manifested itself early in life in the children, the
worst of whom was a boy about 11 years old. The family were
in the hard-working class, and but moderately nourished. The
boy, the worst case, was at school.

Odor.—A symptom of this disease is a peculiar odor which I
have noted, pervading the vast majority of those in the mature
stages of chronic aural catarrh. It is not at all like the odor of
ozœna; it is more like that of saliva. By simply passing one's
tongue over one's finger, and allowing the saliva to slowly evapo-
rate, this odor may be simulated. It cannot be called offensive,
and it is not perceived at any distance from the patient. It
seems to emanate through the nose, and is more noticeable in
females than in males, because in the latter it is usually dis-
guised by tobacco. This odor, I think, is due to a disordered
condition of the follicles of the mucous membrane of the fauces,
mouth, naso-pharynx, and nose.

OBJECTIVE SYMPTOMS.

Appearances in the External Auditory Canal.—It may be said
that in chronic aural catarrh characteristic changes occur in the
external auditory canal. Chief among these is the diminished or
suspended secretion of cerumen. The ear-wax not only becomes
smaller in amount, but often assumes a brittle quality; later it
often ceases to be formed at all. This points to a great altera-
tion in the nutrition of the organ of hearing, and also seems to
indicate a considerable degree of intimate structural relation
between the vessels of the canal and those of the middle ear.
This important excretion's ceasing to be poured into the auditory
canal is succeeded by a dryness and scaly condition of the skin
of the meatus. This latter state favors the growth of asper-

gillus most surely; but, although I have met this parasitic fungus in individuals affected with chronic aural catarrh, I am not prepared to name its occurrence as a characteristic symptom of this disease. Weber-Liel considers its appearance in such cases as not at all uncommon.[1]

Membrana Tympani; Changes in Color.—The membrana tympani usually loses its lustre and transparency in chronic aural catarrh. But as these changes are not always indicative of such a disease in the tympanum, they must never be regarded as of positive value. In some cases of chronic catarrh of the middle ear, the membrana tympani may be thinner than usual, and cases are met with in which the lustre remains unchanged. In the latter instance, the chronic alterations in the mucous membrane of the middle ear have most probably occurred elsewhere than on the inner surface of the drum-head.

Another important fact to bear in mind respecting color-changes in the drum-head is, that, even in those with normal hearing, especially in children, the membrana tympani is not unfrequently rather dull in appearance for longer or shorter periods. The lustre of the membrane is most easily lost; alterations in tenuity are more indicative of a deeper change in structure.

Calcareous Deposits.—Chalky spots may be found in the drum-head of an ear affected by chronic catarrh; but they cannot be considered characteristic of the disease. They are usually traceable to a previous purulent disease in the ear, all other traces of which have gone, for it is not uncommon to find these deposits entirely unaccompanied by hardness of hearing, as has also been noted by Prof. Roosa.[2]

Reverting to European authority, we find, however, that calcareous spots may arise in the course of a chronic aural catarrh, as observed by Moos in a woman more than seventy years old.[3] But this must be regarded as an exceptional case.

After an experience of seven years, in the daily examination of the drum-head, both in Europe and America, I am struck by the general rarity of chalky spots in the membrana tympani of those born in the latter country. It seems that these deposits are much more frequent in those born and reared in Northern

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[1] Op. cit., p. 29.   [2] Op. cit., p. 273.   [3] Roosa, loc. cit.

Europe.   Perhaps the milder climate of the latitude of this city
may account for their rarity in the drum-heads of those born
here.

Changes in Position of the Membrana Tympani.—A much surer
objective symptom of chronic aural catarrh, especially when
joined to opacity and loss of lustre, is a retraction of the mem-
brana tympani.   The drum-head then appears drawn in, and the
manubrium of the malleus foreshortened, the short process of
the latter projects more sharply than usual, and the folds of the
membrana tympani (see p. 52) are very prominent.   The manu-
brium is not only indrawn, but is pulled backwards and upwards,
and the entire concavity and curves of the drum-head being
thus altered, the pyramid of light, normally found in the antero-
inferior quadrant, is very much shifted in position, or it may
disappear altogether (see p. 53).   As the latter reflection depends
on the lustre as well as the curve and position of the drum-head,
and as more or less opacity is found in chronic aural catarrh,
the normal pyramid of light is usually one of the first appear-
ances to vanish from the diseased membrane.   The manubrium
not only appears indrawn, but rotated about its long vertical
axis so as to pull the posterior half of the drum-head into
greater prominence, and to drag the anterior half into a greater
depression.   The causes of this retraction of the membrana
tympani and malleus have been variously assigned by several
distinguished observers.   Politzer is of the opinion that the
swollen and chronically diseased condition of the Eustachian
tube interferes so much with the normal ventilation of the
tympanic cavity as to cause a constant want of air, if not an
entire vacuum, in it.   This want causes a disturbance in equi-
librium in the atmospheric pressure on each side of the drum-
head, and the preponderance of the external air forces the drum-
head in and relaxes the tendon of the tensor tympani muscle.
This in turn may, by fatty degeneration or adhesion, or both,
or by contraction from want of use, fix the drum-head in its
indrawn position.   In such a condition, the want of air in the
tympanic cavity is the prime factor in the retraction of the
drum-head.

Weber-Liel ascribes the drawing in of the membrana tympani
chiefly to the retraction of the tensor tympani muscle.   This
muscle is described by him as a part of the palatal and tubal

muscles (see p. 109). The latter, becoming diseased and under-going fatty degeneration, are no longer able to preserve their proper amount of tension, and hence occur disturbances in the equilibrium of the muscular structures of the middle ear. "In this process (defective motility of the faucio-tubal muscle), the paralysis of the tensor veli sive dilator tubæ plays very probably the chief part, not only because of the resultant persistent and ever-increasing hindrance to the ventilation of the tympanic cavity, but also because this muscle (which, according to my investigations, stands in the relation of antagonist to the *tensor tympani*), when paralyzed, is the chief causative power of the *antagonistic contraction* of the tensor tympani."[1]

Implication of the Sympathetic and other Nerves; Flushing of the Cutaneous Surface adjacent to the Ear.—Among the objective symptoms of chronic aural catarrh may be mentioned implications, more or less frequent, of the sympathetic nerve. It is not uncommon to find " complex disturbances in the correlated tracts of the vagus, glosso-pharyngeus, facial, auricularis magnus, and the accessorius nerves, standing in close connection with aural maladies of this nature. It is also not at all uncommon to find in deaf females, suffering from spinal irritation, muscular weakness, and rheumatic pains in the muscles of the throat and neck, sensitive spots along the side of the neck, behind the sterno-cleido-mastoid muscle, where the auricularis magnus and accessorius arise. Pressure on these spots causes not only pain running down to the shoulder, but also occasions, in the ear on the corresponding side, a feeling of fulness and more or less tinnitus aurium."[2]

In some cases of chronic aural catarrh, especially in the dry form, called by some writers progressive hardness of hearing, a flushing of the skin near the ear is observed. I have seen but three cases in which distinct, deep-tinted, and circumscribed flushing of the surface of the skin near the ear, was connected with tinnitus aurium and progressive hardness of hearing.[3] The history in these cases was such as to lead to the conclusion that this peculiar vascular congestion in the skin may be, in

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[1] Weber-Liel, op. cit., p. 14.   [2] Weber-Liel, op. cit., p. 3.
[3] Three cases of tinnitus aurium and deafness, accompanied by very distinct flushing of the cutaneous surface adjacent to the ear, by the author, in Archives of Oph. and Otol., vol. iv.

some instances, a symptom of aural disease. Weber-Liel[1] has described a case which presented, in one ear, symptoms resembling those observed by Bernard, after section of the cervical sympathetic.

In some cases it must be admitted that the distinctly catarrhal symptoms are much less prominent than the nervous features of the disease, and such cases have given rise to the theory of nervous deafness. But my conviction is that upon ordinary search all such cases, no matter how prominent the nervous symptoms may be, when the case presents itself for treatment, can be traced back to a causative catarrhal trouble in the fauces, Eustachian tube, and middle ear. But it must be admitted that there are many good reasons for assigning to some cases a nervous nature, as may be seen by the following cases :—

CASE. I. I was asked by Dr. T. Hollingsworth Andrews, in May, 1874, to see with him a young lady, 26 years old, of large and handsome figure, unmarried, a resident of the western part of Pennsylvania. Six years previous to the time I saw her, she had suffered from an attack of probably rheumatic facial paralysis on the right side. Within two or three years she had noticed a diminution in hearing, accompanied by an uninterrupted and distressing singing in her ears. The hearing on the right side was reduced to $\frac{3}{60}$; on the left, to $\frac{6}{60}$ for the watch. The tuning-fork, placed on the vertex, was heard better in the *better* ear. The membrana tympani on the right side was more retracted than on the left. The lustre of both was good. The Eustachian tubes were pervious.

There was, in this case, a constant quivering of the buccal and labial muscles, which dated back for a year or more. *There was also a distinct purplish-red flush over the cheeks and neck as far as the clavicle, with an increase in the tinnitus whenever the patient was even ordinarily excited or fatigued.* The application of the constant electric current from a Brenner apparatus, at the time of the examination, did not afford even temporary relief to the tinnitus. I saw the case but once.

CASE II. Mrs. Van C., 56 years old, patient in the Presbyterian Hospital in Philadelphia; a farmer's wife, small and thin.

[1] Op. cit., p. 2.

She states that at the menopausis she experienced a sudden and excessive tinnitus aurium, which, however, has diminished in severity since then, but, though it has become quite endurable, it has never entirely ceased even temporarily. The hearing does not appear to be affected in this case. There is, however, a peculiar vascular congestion or flushing, looking like a car-mine stain, which comes on with any considerable fatigue or excitement, and is attended with an increase in the tinnitus aurium.

This flush extends from both ears, where it seems to start, over each sterno-cleido-mastoid muscle, forward towards the thyroid gland, where the blushes of each side coalesce and extend over the chest and mammæ. At the same time, a similarly tinted blush extends over the nucha and upper part of the back and shoulders, so that the woman appears covered by a carmine-colored cape with the limits already designated. The rest of the skin-surface is sallow. There are at this time some linear blushes running from the ears forwards over the temples, uniting across the forehead. This was truly objective flushing, and altogether different from the subjective flushes, so often felt by women at the menopausis.

Case III. Mrs. McA., of Delaware, a very large, strong woman, aged 45 years, living in a malarial district, and now in her eleventh pregnancy. The patient states that she has had an increasing hardness of hearing, with tinnitus on both sides, for some years. The drum-heads are opaque. In her case there is a *peculiar flush* on the left cheek, corresponding to the worse ear, which becomes apparent on exertion or exposure to heat or cold, and is coincident with an increase of tinnitus aurium. This case grew much better while taking $\frac{1}{45}$ gr. of strychnia thrice daily and using the constant electric current.

The history of these cases adds something to the knowledge of a form of aural disease in which the nervous symptoms pre-dominate.

Since similar flushing has occurred from well-known *direct* lesion of the sympathetic, it is fair to assume that the flushing in the cases I have just narrated must also have been due to an irritation of the sympathetic. In two of the cases, as there were other symptoms of chronic alterations in the organ of hearing, it would seem probable that in them at least, the flushings were

directly traceable to the aural malady. In the second case it may have been but the precursor of deafness.

Circumscribed flushing of the cutaneous surface in any part of the body, whether from external violence or internal causes, is rare and in many respects unsolved.

In a case[1] of direct mechanical violence to the sympathetic nerve, the only known case at that time on record, " the face presented, after walking in the heat, a distinct flush on the right side, and was pale on the left. The right half of the face was very red. The flush extended to the middle line, but was less definite as to its limit on the chin and lips than above these points."

Dr. Wm. Ogle[2] has reported a case of probable destruction of the right cervical sympathetic by abscesses. In this case " the eyeball was retracted, the palpebral fissure narrowed, the pupil contracted, the right side of the face redder and hotter than the left during repose, but after violent exercise or fever, colder. The left side of the face alone sweated, and the right side of the mouth and tongue was complained of as being dry."

In a case[3] under the care of M. Trélat, at the St. Louis, in Paris, in which the sympathetic nerve had been destroyed by an operation for removal of a deep-seated tumor of the neck, " on the day following the operation, the face was deeply congested, especially on the right side, which displayed well-defined patches of violet and red color."

These cases are cited because they present instances of flushing of the face and parts of the head from known and direct lesions of the sympathetic nerve. In the three cases I have related above, there was well-defined flushing without history of external violence to the sympathetic nerve, nevertheless it seems fair to conclude that the nerve was affected from within, and to it treatment would be well directed.

The Condition of the Pharynx and Throat.—On examination, the pharynx, tonsils, and velum will be found to present varying appearances according to the form of the disease.

In the moist form the secretion of mucus will be markedly

[1] " Gunshot and other Injuries of the Nerves." Mitchell, Morehouse & Keen, 1874. Philadelphia.

[2] Medico-Chirurgical Transactions, vol. lii. p. 154.

[3] See Abstract in Med. Press and Circular, p 78, Jan. 1869.

increased, and the glandular structures of the mucous lining of the fauces will appear enlarged and inflamed, their function being of course stimulated by the disease.

The tonsils are usually very much enlarged in this form of the disease, and the velum appears swollen. But this is only an accompaniment of the general catarrh, not the cause of it in the ear nor of the hardness of hearing. It will very often be found that the most swollen tonsil is on the side of the better ear. The secretion of the nose is also very apt to be abnormally great. This form of the disease really deserves the name of catarrh in its strict meaning of " flowing" or " running."

But many cases of chronic aural catarrh do not continue to show this abnormal amount of secretion in the pharynx. In these cases the mucous membrane has either rapidly ceased to throw off large amounts of mucus, or it has slipped at once into an atonic and dry state. In such cases the mucous membrane of the entire pharynx, especially on the posterior wall, is pale and, at spots, apparently cicatrized. It may even somewhat resemble granular pharyngitis without marked secretion.

The *velum* appears rather thinner than natural, as though its muscular structures were atrophied, as indeed they are ; and the *raphe* is no longer directly in the median line, nor are the halves symmetrical in shape and position. A paresis has apparently affected one-half more than the other, and the uvula and the weaker half will be drawn towards the stronger side, which will usually be found to agree with the better ear. All of these changes in the action of the muscles of the fauces must be attributed to the effects of the catarrh.

Loss of Function in the Velum.—The loss of normal mobility in the velum is further seen when the patient is told to phonate the vowel *a* broad. Then, the velum and uvula, instead of rising quickly to shut off the lower from the upper pharynx, will fail to fulfil this function. The uvula either hangs loose and downward, quite relaxed, or it clings to one or the other side, on the edge of the velum. As the patient phonates, the uvula may slip from this position on the velum and hang loosely downward, or it may curve forward. In such conditions, sudden eructation, coughing, or sneezing may at times produce pain in the ear. It is also very noticeable that the act of swallowing cannot be performed rapidly by persons thus affected in the faucial muscles.

Changes in the Voice.—With these alterations in the ear and throat, the vocal functions usually become weaker. The timbre of the voice is altered, and, if the patient has been a singer, the voice is found to be rapidly losing musical power. A kind of hoarseness sets in, when singing or prolonged conversation is attempted. The voice " breaks" or " cracks," and a general sense of fatigue in the throat becomes a prominent and distressing symptom. My observation leads me to conclude that all of these alterations in the throat usually begin to appear before the early morbid changes in the ear. The latter seems to become affected by a passing upward of the throat-disease, through the tube into the tympanic cavity. When once there, a long series of nutrient changes begin, which, with varying symptoms, usually terminate in total deafness; though in some cases, chronic aural catarrh seems to stand still after having diminished, but not destroyed, the function of the ear.

A marked peculiarity of chronic aural catarrh is not only to advance slowly and surely in one ear, but to pass to the other, sooner or later. The changing of the voice, *i. e.* the gradual assumption by the patient of a high and peculiar pitch in the voice in talking, will often aid in diagnosing a chronic catarrhal affection of the middle ear, even when the patient is sure that the aural malady is of sudden advent.

" An explanation of the numerous symptoms of affections of the vocal organs, so often associated with aural disease, may be sought in the direct connection between the acoustic nucleus (by means of the acoustic trunk) and the probable centre of speech in the cortex of the island of Riel. On the other hand, it is important to bear in mind the anastomosis between the vagus and the petrosal ganglion of the glosso-pharyngeal nerve (tympanic plexus, tubal nerves) and the auricular branch of the pneumogastric nerve, which, in this instance, plays the part of a communicating link. During the insertion of a probe into the Eustachian tube of one possessed of good ears, pain is felt in the larynx when the probe reaches the isthmus. This is felt before the person operated on is aware of the presence of the probe in the ear. In perichondritis crico-arytenoidea there is always pain in the ear."[1]

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[1] Weber-Liel, op. cit., p. 35.

Saissy relates that in the records of the Parisian Academy of Sciences for the year 1705, a singular case is accredited: "A young man, 20 years old, lost both hearing and speech after his larynx had been squeezed by a strong man, in a fight. All means tried for the restoration of hearing failed in this case."[1]

Objective Changes in the Eustachian Tube.—As may be inferred, from what has been already said in the preceding pages, the Eustachian tube, being lined with mucous membrane continuous with that of the fauces and of the tympanic cavity, and forming such an important part of the middle ear, undergoes serious and most important changes in chronic aural catarrh. These changes are due primarily to thickening of the lining of the tube, or to obstruction of its calibre by mucus. Hence arise very striking objective symptoms, which become apparent to the surgeon upon using the Valsalvan method, Eustachian catheter, Politzer's inflation-bag, or bougies for dilation of the tube. To all of the processes of inflating the drum, and to the probe, the tube will offer more or less resistance; in some rare instances the inflammatory process may have been so great as to cause an entire closure of the tube at the isthmus.

Upon auscultation of a catarrhal ear, into which some air enters from the catheter, the sound perceived by the auscultator will reveal the presence of mucus in the Eustachian tube, or a narrowing of the same with perhaps a diminution of secretion. The first condition is found in the moist form; the latter sound, that of air rushing through a narrow and dry tube, is of course found in those cases in which the secretion is not in large amount, and in which the catarrh has led to a hypertrophic process throughout the mucous and submucous tract of the tube.

These symptoms of obstruction, usually ascribed to the changes just named, are accounted for somewhat differently by one high authority, Weber-Liel. This observer states that in many cases of asecretory catarrh of the middle ear, or, as he calls it, progressive hardness of hearing, the Eustachian tube is easily permeable to a bougie, but not to air by any means of ordinary inflation. The cause assigned for this obstruction to the entrance of air, is the relaxed condition of the muscular walls of the tube. So great is this relaxation, that the flaccid walls cannot

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[1] Quoted by Weber-Liel, loc. cit.

be forced apart by any of the ordinary means of inflation. Be this as it may, the cause of this muscular weakness, atrophy, or paresis, is, in my opinion, to be considered *secondary* to the catarrhal inflammation. This is analogous to processes in other muscular structures underlying mucous membrane, elsewhere in the body. Thus in the alimentary tract, muscular derangements are constantly found following close upon catarrhal disease of its mucous lining; the same may be said of the bladder and of the lung. In all of these, a prominent symptomatic change, following close upon inflammation of their mucous layer, is the want of proper contractility in the subjacent muscular structure. It would, therefore, seem much simpler to account for the symptoms of muscular derangement in the middle ear, affected by chronic catarrh, in the same way as muscular alterations occurring in a chronically inflamed bronchus are explained.

The mucous membrane of the nose, pharynx, and Eustachian tube may be not only greatly congested and swollen, but extremely irritable, assuming almost an erectile nature. In such cases, merely smelling an irritating substance has been known to produce an instantaneous closure of the Eustachian tube, altered pressure in the tympanic cavity, deafness, and sudden unconsciousness.

Erhard[1] mentions the case of a boy, whose nasal and Eustachian mucous membrane possessed such peculiar irritability that upon applying his nose for an instant to a bottle containing sulphuric ether, all of the above symptoms ensued, not only once, but repeatedly for many days in succession, whenever Erhard desired to demonstrate the case to his pupils. Upon inflating the tympana in this case, consciousness instantly returned. This case points unmistakably to a sudden closing of the tubes, a disturbed equilibrium in the membrana tympani, forcing inward of the chain of ossicles, pressure by this means on the labyrinth-water, and thence to the cerebro-spinal fluid.

Adenoid Growths and Granulations in the Naso-Pharynx.—In a number of cases of chronic aural catarrh, there are found adenoid growths and granulations in the naso-pharyngeal space. Their nature and the symptoms they produce have been very

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[1] Outlines of Physical Otiatrics. Translation in Phila. Med. Times, Jan. 4, 1873.

carefully studied and described by Czermak, Türck, Semeleder, Voltolini, Löwenberg, and W. Meyer.[1]

These growths are described as benignant in nature, and more or less leaf-like or conical in their shape. They are usually situate quite high in the naso-pharynx, are extremely delicate, and hence bleed on being touched. Their height or length rarely exceeds three cm., and their breadth or thickness varies from a few lines in the smallest to one or two centimetres in the largest. As might be supposed, such growths interfere not only with respiration and enunciation, but also with the normal ventilation of the Eustachian tubes and the tympana.

The symptoms are a tendency to bleed whether touched or not, alteration in the pronunciation of certain vocal sounds, as m, n, and ng, and a great change in the facial expression, from the falling in of the alæ of the nose, and the respiration through the mouth, necessitated by the obstruction in the posterior part of the nares. The hearing, too, will in time become greatly lessened from the chronic stoppage in the Eustachian tubes, and the interference to the normal ventilation of the middle ears.

The proportion of aural disease in persons thus affected in the naso-pharynx has been placed by Meyer at 130 in 175. Although not uncommonly I find this condition of the naso-pharynx, the proportion is by no means similar to the above, a fact to be accounted for, very probably, by the milder climate of Philadelphia, Dr. Meyer having made his observations in the high latitude of Copenhagen. A naso-pharynx thus affected is apt to secrete large amounts of tough greenish mucus, the velum may be swollen, and the lower pharynx chronically inflamed. On the other hand, these growths may be present in the naso-pharynx without any marked accompanying changes in the pharynx and velum. Not uncommonly, the altered enunciation, respiration, and facial expression arouse a suspicion of their presence, which is subsequently confirmed by rhinoscopic examination, and manipulation with a probe, the latter causing the growths to bleed.

Symptoms in the Eustachian Tube and Tympanum revealed by Inflation and Auscultation.—Unless there is total occlusion of the Eustachian tube, some air can be forced through it into the tympanic cavity in every case of chronic aural catarrh. To

[1] Archiv für Ohrenh., Bd. ii. N. F. pp. 129 and 241.

accomplish this, the methods employed may be those known as Valsalva's and Politzer's, or that more direct one, with the catheter and hand-balloon. The sounds produced by forcing air into the drum-cavity are easily heard by means of the auscultation-tube. These sounds, however, are greatly modified by the means used to inflate the drum and by the condition of the Eustachian tube, and, very probably, of the tympanic cavity.

In using the catheter it will be found that its calibre and the column of air forced through it, influence the pitch and quality of the sound heard on auscultation. For, the air passed through the catheter, like every column of air passing rapidly through a pipe, will produce in the latter its fundamental tone, dependent upon the length and diameter of the pipe. Hence, in a wide catheter, a fuller and deeper sound is heard ; in a narrower one, a whistling noise. Unless this is borne in mind, the quality of the sound thus produced might be referred to the condition of the Eustachian tube.

Having, therefore, found out, before the catheter is inserted, the general quality and pitch of the sound produced by forcing air through it from the hand-balloon, the surgeon can, with advantage, study the sounds resulting from inflation of the tube and tympanic cavity by the catheter. These sounds will be found to be very different from those obtained even in the same ear by Valsalva's or Politzer's inflation. In the former, there is no instrument employed which, of course, excludes any sounds from such a source; in the latter, the instrument being so remote from the fauces, no sound produced in the hand-bag is conveyed into the middle ear and thence to the ear of the auscultator. In both of these latter methods of inflation, only the movements of the natural parts concerned and the thud of the entering air are perceived. In that respect they are certainly superior to the Eustachian catheter, since, by their use, the condition of the tube can often be determined without confusing sounds originating in the instrument. The catheter, however, is of the greatest aid and usefulness, if it be but remembered that the quality of the sound made by the air forced into the tube, is influenced by the calibre of the instrument.

Air forced into the normal Eustachian tube and middle ear by artificial means, conveys to the auscultator the impression of air passing with freedom through an unimpeded tube. When

the methods of Valsalva or Politzer are used, the air enters with a thud, the ear seems to have been filled by the air sent in, and the impulse thus conveyed upon the membrana tympani reveals itself most distinctly to the ear of the auscultator joined to the ear of the one operated on by means of a rubber tube.

Auscultation by the same means, applied to an ear the Eustachian tube of which is narrowed or clogged by the products of chronic inflammation, reveals a different physical condition of the ventilating apparatus of the tympanic cavity. If mucus is present, bubbling sounds will be heard; if the tube is dry, then of course a dry sound. At the same time the tube seems narrowed, for the quality of the sound made by the air inflated is that of air passing through a narrow tube.

Air inflated through a normal Eustachian tube enters independently of the act of swallowing; in the tube narrowed or altered by chronic catarrhal inflammation, this act on the patient's part aids greatly in the artificial ventilation of the drum-cavity. So resisting is the diseased Eustachian tube to ventilation, that in some cases air can be forced through only during swallowing. This latter condition is highly characteristic of alteration in the tube.

The Objective Effects of Inflation upon the Membrana Tympani. —The effects of inflation upon the membrana tympani are among the most important objective symptoms. In some respects they have been duly considered, but there are some signs which are deserving of special notice. One reason why the action of the membrana tympani during inflation has not been as highly rated as it should be, is due to the fact that there is only one method which can be employed, Valsalva's,[1] during which the surgeon can inspect the drum-head and the effects produced on it by the motions of the contents of the tympanic cavity. More or less bulging of the drum-head will be caused by inflation. If the handle of the malleus is held retracted, by alteration in the mobility of the tendon of the tensor tympani, this bulging of the membrane will occur behind and before the manubrium; but if the manubrium is not held in as above suggested, then it and the membrane will be moved more or less as a whole. At the same time, if there is movable fluid in the

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[1] This mode of inflation consists in the patient's holding his nose and forcing air, by powerful expiration, into the tympana while the mouth is closed.

cavity of the drum, it will be forced against the membrana tympani and modify the picture presented to the observer. Bubbles may be seen then distinctly through the membrane, or inspissated secretion may be found to change position in the drum.

A most interesting and instructive change, produced by inflation, in the appearance of the drum-head, is the forcing outward of depressed spots or cicatrices. Unless this symptom is sought for, and promptly noted after the air is forced into the tympanum, it may escape notice.

Very often depressed cicatrices are considered retractions adherent to the inner tympanic wall, but on inflation these depressions may not only return to the plane of the rest of the drum-head, but not uncommonly they project beyond it, into the auditory canal, forming thus bladder- or blister-like spots. In some cases these are filled only with air; in other cases, in fact often, they are filled with brownish fluid, which will give them an amber tint.

Not only will these appearances come out on the drum-head by inflation, but they can be produced very easily under suction by Siglé's speculum.

This latter method of examination of the drum-head is of the greatest value, for, when the tube is stopped up and absolutely impervious to air, Siglé's pneumatic speculum or its equivalent becomes the only means of producing movements in the drum-head, and secondarily of the contents of the drum-cavity.

Not uncommonly inflation of the tympanic cavity, especially by Valsalva's or Politzer's method, produces objective sounds, readily audible without the aid of the auscultation-tube.

Especially is this observable when the entire drum-head is flaccid and easily moved to and fro, or when, in a comparatively normally tense membrane, flaccid scars are found.

The sound produced in either instance is that of a loose crackling and flapping of the flaccid tissue. In a case recently observed, so loud was this flapping-sound that it was heard across a large room, not only during Valsalva's method of inflation, but also during rapid breathing through the congested nares, the mouth being kept closed.

Causes of Chronic Catarrh of the Middle Ear.—Very few patients can give a satisfactory cause for their disease. In fact,

it is not an easy task for the physician to assign the positive cause for chronic aural catarrh in the majority of cases. It does seem that very often chronic catarrh of the middle ear is caused by cold. It would be safer, in most cases, to say that chronic aural catarrh is found associated with, rather than produced by, certain diseases; though the latter may have much to do in its aggravation and chronicity. Thus, chronic catarrh of the ear is frequently observed joined with chronic catarrhal disease of the mucous membrane elsewhere; phthisis; grief and weeping; nursing the sick, especially by night, with loss of sleep; progressive locomotor ataxia; sciatica; general neuralgia, but especially neuralgia of the fifth nerve; insanity; intemperance and debauchery. It may also be found following close upon pregnancy, the menopause, uterine diseases, continued fevers, any of the eruptive fevers, mumps, great shock after fracture of limbs, sedentary life, rheumatism, gout, and, perhaps, secondary syphilis. In this country, within the last few years, I have observed a number of cases of chronic aural catarrh traceable to exposure, by sleeping on the ground, while in the field as soldiers during the recent war.

Anglo-Saxons born in tropical countries, as well as those whose parents are, one an Anglo-Saxon, the other a native of a tropical region, seem specially liable to chronic aural catarrh. This has been remarked by Hinton, of London, who has had large opportunity of seeing such cases among the English with connections in India. In our country I have observed such a tendency in children born of Anglo-Saxons in Mexico and South America.

In these cases Hinton has observed a thinning of the membrana tympani in its posterior segment. In the few cases I have seen, a similar condition of the drum-head was noted. I have observed a number of cases of chronic catarrhal deafness in young women from eighteen to thirty years of age, associated with, and apparently caused by, ozæna and menstrual irregularities; according to my experience, ozæna is more frequent in the female than in the male.

Hunting, which often brings with it a wetting, and especially duck-shooting, seems to be a cause of chronic aural catarrh in men. Also, diving and ducking the head in cold water most surely produce a thickening of the drum-head and lead to

a chronic catarrhal state of the tympanic cavity. Mill-hands of both sexes are specially liable to chronic catarrh of the middle ear; as also are carpenters, boiler-makers, and female domestics. In the first class, the noise, the confinement of the work, and the dust certainly tend to produce catarrh of the air-passages, general debility, and aural disease.

Carpenters are constantly exposed to the varying temperatures around a new building; the latter cause, added to their liability to perspire and the fact that they are generally insufficiently clad, makes them very often the victims of aural disease.

Boiler-makers' and telegraph operators' deafness may be due as much to nervous exhaustion from continuous shock, as from catarrhal disease; but the latter is generally found to have a part in the train of symptoms.

Female domestics, and females forced to do their own house-work, are constantly exposed to great changes in temperature, because their labor takes them one moment to the hot kitchen and the next moment to the cold court or "flat" to hang up wet clothes, or from cooking in the house to scrubbing in the open air. To these facts may be added that such women are usually found in damp skirts, and when they rest for a moment it is usually without any covering for the head, at the front door or at a window, in a draught.

These are some of the more manifest causes; there are other causes assigned by patients, but these are chiefly fanciful. Since, however, some of these causes have been given by really intelligent people, it may be well to cite a few: thus, a lady informed me that her deafness, markedly catarrhal, was ushered in by a hasty journey to Europe and back again to America. Two persons of intelligence have assured me that they became deaf in Switzerland, as they thought, from the chilly air and damp rooms of hotels. Others attribute their hardness of hearing to blows on or about the ear, excessive night study, editorial work, and sudden noises near the ear, as of firing guns, etc. The latter cause very frequently produces an injury of the labyrinth, but it, like many of the causes given by patients, has only served to call attention to the ear *already* diseased by chronic catarrh. In some cases *no reason* is given; it seems that the patients in such cases have been growing deaf so long that they have become used to it. This is specially noticeable in children

who have become deaf, or in adults who became chronically deaf while children.

One might suppose that deafness for which no cause is assigned, would be found in neglected children of the poor. But I have been surprised to find that children of the rich and educated—children well cared for—are frequently placed under treatment for hardness of hearing for which no reason is given by the parents, nor can the latter be assisted by the surgeon in recalling any probable cause. These cases are almost invariably found in families having, apparently, an hereditary tendency to deafness. The treatment of chronic aural catarrh is to be considered in the following chapter.

CHAPTER III.

TREATMENT OF CHRONIC CATARRHAL INFLAMMATION.

In treating chronic catarrh of the middle ear, the particular form presenting itself, either the moist or the dry, must be kept sharply in mind. It is very evident that grave mistakes have been made in applying empirically one form of treatment, steam for example, to every case of hardness of hearing which could be attributed in any way to chronic catarrh. A moment's reflection would surely show the folly of using such a remedy in a case of moist catarrh. On the other hand, some such relaxing or softening means may be of value in the dry and sclerotic forms of catarrhal deafness.

The treatment of any case of chronic catarrh of the ear resolves itself very quickly into the question, what will restore the middle ear to its normal condition of containing air and conducting sound? The answer to this will depend upon the power to decide, whether the interference to hearing is due to an excess of secretion in any part of the mucous lining of the middle ear, or to an absence of such a secretion combined with the thickening, stiffening, or drying of any or all the parts concerned in conducting sound. With this divergence in form, or in these different stages if you will, comes a vast diver-

gence in treatment. And, at the outset, it must be confessed that treatment applied to the moist, secretory forms is far more satisfactory to patient and physician than that applied to the so-called dry, asecretory, " proliferous," " chronically thickened," or " anchylosed" forms. Doubtless, many cases have been placed in the latter category, that of the dry form, which really should have been placed in the former class. Among recent authors, Mr. James Hinton of London has brought out this fact most brilliantly before the minds of those specially interested in the treatment of aural diseases. That distinguished writer has shown, that a large number of cases formerly diagnosed as purely dry chronic catarrh of the middle ear, are really cases of inspissated accumulations in the tympanic cavity, and by their removal hearing is restored. Of course, those cases in which masses of fluid behind the drum-head cause the latter to bulge, have long been recognized by aurists, but Hinton, Schwartze, and Weber-Liel have gone really a step in advance by proving that many cases of what was once called hopeless thickening and hardening of the drum and its contents, are really very remediable examples of simply hardened old secretions in the drum. Without doubt such is the case, but the great obstacle in the way of their successful treatment is the impossibility of always diagnosing them. The more fluid these old accumulations are, the more readily are they recognized ; the older and harder they are, the more difficult they are of recognition through the drum-head. But it seems, to fair judges, that a more hopeful era has begun in the treatment of many cases of chronic catarrh, by the mere knowledge that such cases may depend on the presence in the tympanum of hardened mucus, the remnant of successive acute and subacute catarrhs, and not on an organic change in the tympanic tissues.

Constitutional Remedies and Hygiene.—Constitutional remedies are of the greatest value in the treatment of chronic aural catarrh. They are most efficient when chosen from the list of so-called alterative medicines or alterative tonics. The preferable drugs are, perhaps, iodide of iron, iodide of potassium, and bichloride of mercury. These are especially adapted to the cases presenting strumous features, glandular enlargements, and the more secretory characteristics. In the dry form, I have

obtained the best effects by using iron and strychnia, and the combination found most desirable is wine of iron with strychnia (gr. ss–j to f℥iv). The dose of such a mixture should be a teaspoonful thrice daily.

For some time past, internal remedies have fallen into disuse in the treatment of aural diseases, but lately, it has seemed best to return to them, fully aware that they are not to be relied on for all the aid needed, but as admirable adjuvants to the local treatment. Mr. Hinton has advised[1] the giving of perchloride of mercury; this he has given in doses of $\frac{1}{36}$ or $\frac{1}{48}$ gr. two or three times a day, with the perchloride of iron, and he believes this combination is often useful in the dry or proliferous form.

Applications to the Nares, Naso-pharynx, and Throat.—Medicated applications to the nares, naso-pharynx, and fauces are of important aid in the treatment of chronic aural catarrh. From what has been said elsewhere, it will be seen that from the nature of the origin of this disease in many instances, treatment of the parts just named would be indicated. In by far the vast majority of cases of chronic catarrh, more benefit is derived from the proper treatment of the nares and pharynx than from direct medication of the tympanum. The latter is probably not as often reached by injections aimed at it as is supposed, and, if reached by such substances, is probably more frequently injured than not. In every case of chronic aural catarrh, the lesion in the tympanum either has been, or still is due to want of air in the cavity. This, of course, has been due chiefly to the occlusion, either temporary or permanent, of the Eustachian tube. Such being the case, the treatment must aim either at the removal of this obstruction to ventilation of the tympanum, or to its effects. The latter may have obtained so long as to be irremediable, but the first aim in the treatment should be to restore the tube to its physical function as conveyer of air to the tympanum.

There are, however, some cases of chronic catarrh of the middle ear, in which the Eustachian tube is found to be pervious, both to natural and artificial inflation, and yet the hearing is much impaired. In these cases it will be found that the lining membrane of the tympanum has undergone a change,

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[1] Op. cit., p. 243.

mostly a thickening, or that the tympanic cavity is filled with inspissated mucus, the result of passed subacute catarrhs.

Although the tube is found pervious in these cases when examined by the surgeon for the first time, there must have been a period in their history when the tube was stopped up and aided in bringing about the condition of the drum-cavity just mentioned.

It may be said, therefore, that these two chief forms, viz., (*a*) a closed tube with an empty tympanum, and (*b*) the pervious tube with a full tympanum, are classes into which chronic aural catarrh may be placed. A third class (*c*) may also be found composed of a union of the two forms in the same ear. If fluids ever can be or should be thrown into the tympanic cavity, the class *c* would afford the proper opportunity.

Irrigation of the Naso-pharynx by means of the Nasal Douche.— Any form of irrigation applied to the naso-pharynx may be called a nasal douche. But this name is specially applied to an instrument devised by E. H. Weber, during his physiological studies on the velum and pharynx.

It consists of a bottle to the lower part of the side of which a hose is attached. The latter has a nose-piece, best made of glass, olive-shaped, which fits snugly into one nostril. In this country and in England, such an instrument is usually called Thudicum's nasal douche, after him who introduced it to the notice of the profession in the latter country. It is, without doubt, the best means surgery possesses of irrigating the nares and naso-pharynx. Accidents to the ear have happened by *improper* use of the nasal douche. When it is carefully and correctly applied, however, I do not know that water has ever been forced by it into the middle ear.

The following rules will be found to give the greatest assurance of safety. And, so far as I have observed, no accident has ever happened where they have been fully observed:—

1. The vessel containing the fluid to be injected must not be higher than the forehead of the patient.

2. The forehead must not be inclined forward too greatly, for if it be, the fluid enters the frontal sinuses.

3. The fluid used in each case must be tepid, and in bad weather the patient should not leave the room for a quarter of an hour after the use of the douche.

These are substantially the rules given by Dr. Seyfert,[1] of Oderan, as in force in the celebrated clinic of Prof. Wendt, of Leipzic.

The discovery of the nasal douche is attributed to E. H. Weber, while he was making his experiments on the organs of smell. According to Dr. Seyfert (*loc. cit.*), Theodore Weber, of Halle, was the first to utilize the fact that a stream of water passed through one nostril will escape through the other, after passing through the naso-pharyngeal space. This is due to the well-known reflex action of the velum palati, which causes it to retract and shut off the naso-pharynx from the pharynx.

Where the above general rules have been followed, Dr. Seyfert states that he has never known a case of secondary inflammation to occur.

A universal mistake of physicians and patients is to place the vessel holding the fluid at a very great height above the head. The surface of the fluid in the douche-bottle must have only that elevation above the nose sufficient to carry the irrigation into the naso-pharynx.

If the vessel is held or placed higher than this, it is plain that the fluid used may be forced too high, even into the frontal sinuses and tympana.

Before the nasal douche is used by the patient, the surgeon should satisfy himself that there are no obstructions to the passage of the water through either nostril. An obstacle to the return current of the irrigating stream would be just as dangerous as too high a position of the source.

For by such hindrance, the water entering the naso-pharynx might easily be forced into the middle ear. The patient's head must be held erect. If it is bowed forward the water is very likely to enter the frontal sinus and the tympana, since these parts are thus more likely to be brought below the hydrostatic source.

After using the douche the patient should not go immediately into the open air. It will be safest to apply the douche in a pleasantly warm room, and to remain there at least a quarter of an hour after the irrigation is ended. These precautions are absolutely imperative in winter time.

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[1] Ueber die vielfache Anwendung des Irrigationsapparats, Wiener Med. Presse, Nos. 33, 34, 36, 1872.

In summer, if the douche is used, the temperature of the room will not demand so much attention. But going into a cooler place, or sitting in a draft of air, must be avoided even in summer time, after using the nasal douche, just as carefully as after a warm bath.

Patients often ask how much fluid they are to use in the douche, and how long the current should be allowed to flow through the nares without being interrupted? To the first question, it may be said that half a pint is enough to begin the use of the douche with; the amount can be increased gradually as the patient becomes better practised in the use of the instrument. The second question is more important, and to it the reply may be given that at first the current must run but a short time through the nares without interruption, say during the short holding of the breath. Gradually the patient learns to breathe comfortably through the mouth, while the current of water runs through the nares. When proficiency in this respect has been attained, perhaps an entire pint or even more may be run through the nostrils and naso-pharynx without interruption. But at the outset of the employment of this apparatus, the patient must be told of the importance to him of not gasping or gulping during the operation. It has seemed to me that the latter danger is most easily avoided by allowing the current of fluid to run through the nares only as long as the patient can quite comfortably hold his breath.

In the warm water used in the douche, all that will be most usually necessary at first will be common table salt, in the proportion of one-half tablespoonful to the pint of fluid. In many instances I have found it very beneficial to use a preparation of salt known as " sea-salt." This is said to be the result of evaporation of sea-water; it surely is stronger to the taste than common table-salt, and doubtless contains more haloid elements than it. It is quite agreeable to patients, but, being stronger than common salt, must be used in the proportion of a large teaspoonful, finely crushed, to a pint of water.

In ozæna, in addition to the common salt, a few drops of a strong solution of permanganate of potash may be thrown into the water, until the latter becomes thoroughly impregnated with it. As a rule, a saturated solution of this drug may be written

for, and the patient instructed to use about 10–20 drops to the pint of water.

Gruber's method of injecting fluids into the nares and the naso-pharyngeal space consists in throwing, by means of a syringe, fluid into one nostril, the other being stopped by the finger of the surgeon. The fluid, upon reaching the naso-pharynx, causes the velum palati to rise up and shut off the upper from the lower pharynx, just as it does in the case of the nasal douche. As the fluid, however, is deprived of its only way of escape outward by the stopping up of the nostril as stated above, it must seek the Eustachian tubes. " According to the force with which the syringe is emptied, according to more or less firm closure of the outer opening of the nostril and the superior pharyngeal space underneath, further, according to the degree of perviousness of the Eustachian tubes, by this method the fluid can, with greater or less force, be thrown into the middle ear, while the rest of the fluid flows out through the re-opened nose, and in many instances a small portion escapes through the mouth."[1]

This is a method which should be employed only by the surgeon; it is not advisable to give it into the hands of the patient. If it is brought into requisition, the surgeon has a ready means of controlling the force with which the injected stream enters the naso-pharynx. According to the direction of the proposer[2] of the procedure, only two fluid ounces are to be injected at once; he usually employs a weak solution of borax (one drachm to the pound of water), recommending that the drum-head be inspected immediately thereafter, and that the air-douche in some form be used to modify by displacement the effects of any fluid which shall have entered the tympanum, if such modification be demanded.

Applications to the Eustachian Tube.—In most cases of swelling and narrowing of the Eustachian tube, the use of inflation simply will be quite sufficient to overcome the obstacle. If, however, after the catheter is known to be properly placed in the mouth of the tube, no air is forced into the tympanum, the tube may be considered occluded, and resort may be had to the

    [1] Gruber, Ohrenheilkunde, p. 264, Vienna, 1870.
    [2] Gruber, Monatsschr. f. Ohrenh., Jahrg. vi. No. 8.

Fig. 68.

careful use of a probe of catgut, laminaria, or whalebone. Perhaps the most desirable form of bougie for this purpose is the small catheter-bougie of Weber-Liel; it is best employed with a graduated catheter devised to go with it. All bougies or probes, for use in the Eustachian catheter and tube, should first be fitted into the catheter, and marked at two points, on that end nearest the surgeon. The first point should correspond to the exact length of the catheter used, which will indicate when the distal end of the probe is about to leave the beak of the catheter and enter the tube; the second point should be as distant from the first as the length of the amount of probe it is desired to push into the tube. This may vary from one to one and a half inches. Inflation should be done as thoroughly as possible before the probe is inserted, never afterwards, for fear of emphysema. Even the most gentle manipulation may abrade a diseased mucous membrane, and then an inflation might produce the above-named undesired complication.

Various applications have been advised and made to the mucous lining of the Eustachian tube, in order to allay chronic inflammation. In most cases they do more harm than good; beyond weak solutions of bicarbonate of soda (gr. v–f$\mathrecal{z}$j), and sulphate of zinc (gr. j.– f$\mathrecal{z}$j), all injections into the Eustachian tube are of risk. Steam is not to be considered anything more than useless; it is not harmful, unless carelessly applied, when the patient may be scalded.

In all cases, the fluid injected either into the mouth, or further into the calibre of the tube, should be warmed. Great

A.   B.
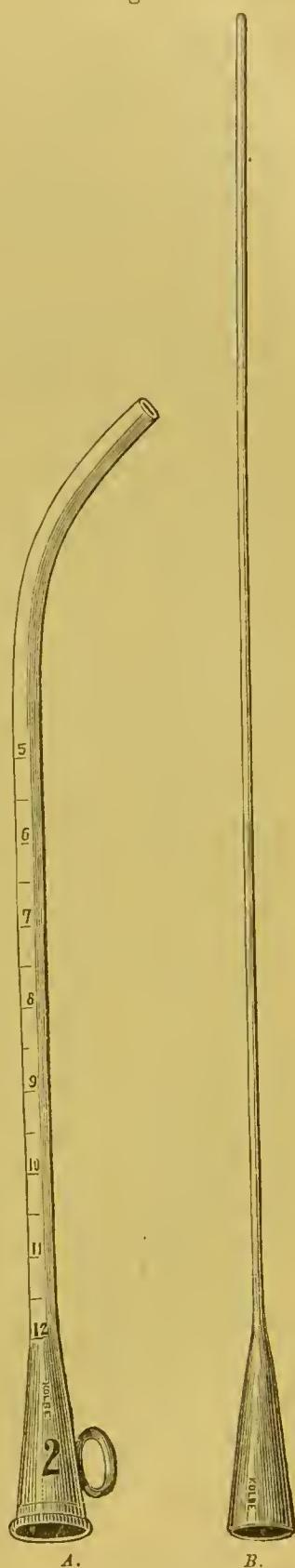
Weber-Liel's graduated metallic Eustachian catheter A., for passage of the small bougie-catheter of gummed silk B.

benefit may result from making various applications to the mouth
of the tube, but no further inward, in chronic catarrh of the
middle ear. In this way, applications to the nares and naso-
pharynx act in this disease. Much good may be thus done by
touching the faucial region of the tube with nitrate of silver in
solution. In order to accomplish this, an aluminium cotton-
holder, such as is found in all surgical instrument-makers'
shops, may be made to carry up behind the velum the fluid to
be applied. The point of the probe may be directed towards
either tube, or, if both tubal mouths are to be touched, the probe
may be held in the median line, behind the velum. Then the
natural reflex action of the pharyngeal and palatal muscles will
tend to bring the mouths of the tubes towards each other and
the probe lying in the median line. Such a mode of application
is especially necessary when granulations or ulcers exist in the
naso-pharyngeal space. Such a condition may exist without
any marked disease in the pharynx below the velum. Some-
times the first real indication of its existence is obtained by the
blood found on the cotton-tuft at the end of the probe when it
is withdrawn from the naso-pharynx.

The treatment of adenoid and polypoid growths should con-
sist in their evulsion or cauterization, and in subsequent appli-
cations of astringents to the naso-pharyngeal space. The
mechanical destruction of these formations, however, is painful
and inconvenient, while their cauterization is simple, and in
most cases all that is needed.

It has been proposed by Dr. Meyer,[1] to crush and tear these
adenoid bodies by means of an instrument, somewhat like a
lithotrite, to be introduced through the nares. An index-finger of
the surgeon is to be inserted at the same time through the mouth
and behind the velum, so as to direct these growths between
the prongs of the crushing implement. But in many cases it
will be necessary only to wound these growths with the finger,
or a probe armed with a large tuft of cotton, and then apply a
solution of nitrate of silver to the naso-pharynx, by means of
the last-named instrument. After the application of silver,
which may be in strength varying from 10–20–30 gr. to f℥j of
water, astringent solutions may be employed by means of the

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[1] Archiv f. Ohrenh., Bd. ix.

nasal douche.   Salt and water, in the proportion of a tablespoon-
ful of the former to a pint of the latter, will usually be all that
is required, but if a stronger fluid appears to be demanded, sul-
phate of zinc, in the strength of gr. i–ij to f℥j of water, may be
used, and, if there is an offensive odor to the discharges from
the nares, solutions of permanganate of potash may be em-
ployed.

Politzer[1] finds that in cases of adenoid growths in the naso-
pharynx, which bring about swelling and closure of the mouth
of the Eustachian tube and hardness of hearing, touching the
affected parts with nitrate of silver is more effectual than cutting
or dragging away the new growths.

Excision of the Tonsils.—This operation I consider rarely,
if ever, necessary for the relief of hardness of hearing or deaf-
ness, simply because the altered function of hearing is in no
way dependent on the tonsillar enlargement.

The larger tonsil is often on the side of the better ear ; some-
times on the side of a perfectly normal ear, and not uncommonly
enlarged tonsils are found in those with perfect hearing.

When enlargement of the tonsils is associated with deafness,
they are to be regarded simply as symptoms of a catarrhal con-
dition which has also brought about alteration in the glandular
structures of the naso-pharynx, Eustachian tube, and in the
middle ear.   Their violent excision (and excision is always vio-
lent) is worse than useless—it is positively harmful and always
alarming.   If the tonsils are enlarged and interfere with respira-
tion and enunciation, they interfere at the same time with the
proper ventilation of the Eustachian tube and tympanic cavity.
They may therefore be diminished in size by the application to
them of London paste.   A small tuft of cotton on the end of a
cotton-holder may be smeared with this and then forced into
the clefts or gaping follicular openings in the tonsil.   This is
never alarming to the patient, nor painful, or at most only pro-
ductive of slight aching for a short time, and has the effect of
causing a shrinkage rather than a destruction of the gland.

I am all the more convinced of the futility of excision of the
tonsils for hardness of hearing, because the *largest tonsils* I have

[1] Zur Therapie der mit adenoiden Vegetationen im Rachenraum complicirten
Erkrankungen des Mittelohrs.   Archiv f. O., Band x. p. 55.

seen were the successors of excised ones. They might almost be regarded as recidives of a morbid growth, like those succeeding fibrous tumors of the lobule.

Clipping the Uvula.—In some instances an elongated uvula keeps up a constant irritation of the fauces and posterior wall of the pharynx, thus contributing to an aggravation of an aural catarrh. All that is required in such cases is to clip off the redundant mucous membrane, carefully avoiding an ablation of the muscular part of this important appendage to the velum. A removal of such a fold of mucous membrane is generally stimulation sufficient to excite the rest of the uvula to contraction. The entire removal of the uvula is as reprehensible as it is common.

Applications to the Cavity of the Drum.—That which was said against applications to the cavity of the Eustachian tube may be repeated here. Few applications which are aimed at the tympanic cavity ever reach it. If they did they would probably do more harm than good. To render the Eustachian tube pervious to air, and hence to ventilate the drum-cavity, is more important than to inject fluids into it, unless, the membrana tympani being perforated by disease, a means of escape of medicated fluids is afforded.

Vapors of iodine, ether, or chloroform may be of assistance in stimulating a delicate but diseased mucous lining, but it would be just as wise to fill, with a fluid, an air vesicle in the lung by the way of a bronchial tube, as to fill up the tympanum, if one could, by injecting fluids through the Eustachian tube, in chronic aural catarrh, unless there is evidence of inspissation of mucus in the drum-cavity. In such cases, weak and warm solutions of bicarbonate of soda (3–5 gr. to f℥j) are of service. But even with these, great caution must be observed. In all cases in which injections thus directed have apparently produced good results, I have felt inclined to ascribe the benefit to the gentle stimulation and ventilation of the Eustachian tube, rather than to the direct contact of the injected fluid with the cavity of the drum. The latter is an air cavity, and resents the presence of fluid.

Operations with the Knife on the Drum-Head.—When it has been found impossible to send into the tympanum as much air as seemed demanded, resort has been had to the knife. And the

mere incision, with the subsequent admission of air to the drum, has had much more to do with the good result than the choice of the particular spot of the operation. This is proven by the well-known fact, that, no matter where the perforation is made, the hearing, which at first has been increased, has diminished as soon as the opening in the drum healed. And this, as every surgeon knows, occurs sometimes even in a few hours.

Space forbids my entering upon the history of cutting operations on and through the drum-head. This subject, furthermore, has been most ably and exhaustively treated by Profs. Schwartze, of Halle,[1] and Roosa, of New York,[2] to both of whom I am largely indebted for the few historical facts that I shall give here. To those interested in going further into the subject, these two works will prove of the greatest aid.

The proposal of the operation of cutting through the membrana tympani is supposed to have originated with Johannes Riolanus, of Paris, in 1650; Sir Astley Cooper, one hundred and fifty years later, performed the operation in several cases, with apparent success, but subsequently abandoned it on account of his want of encouragement. About seventy-five years before Sir Astley Cooper's operations on the drum-head of man, Cheselden perforated the drum-heads of dogs, and believed that the latter were not only not made deaf by it, but that they became more sensitive to some sounds. In the latter part of the eighteenth century, the operation appears to have fallen into the hands of quacks, and to have been disregarded by the regular practitioners: a reaction too often found when the latter, in their enthusiasm, make use of an operation in a multitude of cases, whether suitable or not.

The indications for the operation had been very vaguely given up to 1800, when Himly in Germany, and Sir Astley Cooper in England, proposed to make use of the operation of perforation of the drum-head in closure of the Eustachian tube. Cooper operated in a number of cases, with a variable success; but as he operated rather empirically, simply for deafness arising from closure of the Eustachian tube, a condition he does not seem to have been fully able to diagnose, he soon ceased to obtain

[1] Archiv f. Ohrenh., Bd. ii. pp. 24, 239, 245.
[2] Treatise on the Ear, pp. 319–344.

results as good as those he first appeared to have obtained, and he then abandoned the operation entirely. Again, the unfortunate reaction in the minds of the regular profession, and naturally enough, again the operation is found almost entirely in the hands of quacks, with not only no good results, but apparently most disastrous ones. Himly now threw a ray of light into this surgical night, by pointing out the truth, that the operation, when it had proven of benefit, was in exceptional cases of deafness due to hermetical closure of the Eustachian tube. But the operation ceased to be regarded with favor, because it had been widely and ignorantly applied; and Wilde is found obliged to speak in defence of the operation, since some had condemned it as dangerous to life—which, however, they could not prove.

As Dr. Roosa has said: "From this chaos of ill-defined indications and imitative experiment, there came out one fact in proper form. That one fact was this: That it was preëminently proper to perforate the membrana tympani in order to remove mucus, blood, or pus which could not find an exit through the Eustachian tube." This has been shown by the operations of Cooper, Itard, Saunders, and Schwartze.

But, as a great demand has ever been, and still is, made on the aurist for relief from chronic, neglected catarrh of the middle ear, without fluid accumulations in the latter, but with every symptom of sclerosis and retraction of the membrana tympani and even of deeper parts of the sound-conducting apparatus, assistance has been sought in various forms of incision and excision of the membrana tympani; in the maintenance of permanent perforations in it; and in tenotomy of the tensor tympani muscle.

Various forms of incision and excision of the membrana tympani for the relief of hardness of hearing *not dependent on accumulations of fluid in the tympanum*, but upon chronic thickening, hardening, stiffening and retraction of the membrana tympani and other parts of the sound-conducting apparatus of the middle ear, have been proposed by several authorities. The operations about to be named have been undertaken with no empirical intent, but with a knowledge of a clearly diagnosed condition of the auditory apparatus. This must be said of them as preëminently distinguishing these from previous operations

on the drum-head; though the best results of paracentesis membranæ tympani are obtained when fluid has collected in the drum-cavity. When the membrana tympani is indrawn, Lucæ and Politzer have proposed *to incise the folds of the membrane*. Gruber has advocated repeated prickings or incisions, and even excision of parts of the drum-head (myringectomy); while Wreden has proposed, but probably abandoned, a heroic treatment consisting in excision of the handle of the malleus, the chief object in this procedure being to retain a permanent opening in the membrana tympani. It is hardly necessary to say that such an operation, even of so distinguished a man, must be deprecated.

Repeated incisions through cicatrices, or an incision through the posterior fold of the membrana tympani, most surely lead to good results in many cases of progressive hardness of hearing. In the former instance the benefit is due to the tightening of the previously flaccid part of the drum-head, which ensues with the healing of the cuts; in the second instance the drum-head, already too tightly stretched, is freed, and very often it and the chain of ossicles will swing more freely in consequence of this simple operation. With the head of the patient gently supported, and the canal properly illuminated, by light reflected from the forehead mirror, the incisions may be made best with a spear-headed knife, the shaft of which should be six cm. long, and curved at an angle of 45° from the hard rubber handle.[1]

Similar procedures are recommended by Prof. Gruber[2] for the correction of anomalies in tension of the membrana tympani. The same authority has also suggested to excise a piece of the drum-head by means of an instrument arranged especially for the operation.

The great aim of otologists, from the time of Paroisse to the present moment, has been, and still is, to make and retain a perforation in the membrana tympani, in a manner at once simple and free from danger. If such a perforation could be obtained, it has been supposed, and now quite amply substantiated, that the hearing, in many cases of chronic aural catarrh, would be improved. To attain this end, numerous suggestions

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[1] Prof. Politzer, Wiener Med. Wochensch., 1871, Nos. 1 and 2.
[2] Lehrbuch, pp. 581–582.

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have been made: as, to keep the perforation open by means of a triangular-shaped sound (Paroisse); to insert into it a bougie (Saissy), or, small solid or hollow bodies (Philippeaux and Frank); but as they have proven of no value, it will be better to confine the attention to the few exceptional forms which have seemed to offer reasonable aid.

The simplest, safest, and most efficient means of retaining the artificial perforation in the drum-head, is by means of a small, hard rubber eyelet, as suggested by Politzer.[1] The eyelet, with a furrow on its outer surface— its general shape being that of a miniature barrel—is fastened to a piece of fine silk or cotton thread, and then inserted into a small cut in the membrane, at any chosen point. Prof. Politzer has devised, for the inser-

Fig. 69.

POLITZER'S EYELET AND EYELET FORCEPS.

tion of the eyelet, a special kind of forceps. These forceps are curved and so arranged, that when at rest the points of the branches are in contact. At the distance of $1\frac{1}{2}$ cm. from the point there is fastened to one of the branches a short round pin, just long enough to touch the opposite branch. When the branches are made to approximate each other at the angle where they are curved, the aforesaid pin near their points forces the latter apart. The instrument is small, being not quite 11 cm. long, and made to work smoothly but firmly, so that if an eyelet be placed between the points, it is held there firmly until it can be carried to the perforation in the membrana tympani. A gentle pressure at the angle on the handle, now frees the eyelet, the latter is left in the artificial opening in the drum-head, and the forceps are withdrawn. The thread attached to the eyelet provides a means of pulling it from the ear, when such a procedure becomes necessary. If the eyelet becomes clogged with dried mucus, Prof. Politzer has found that a drop of glycerine, placed in it by means of a Pravaz syringe, will soften such an obstacle and permit of its being removed by means of a stiff bristle.

[1] Wiener Med. Wochenschrift, 1868 and 1869.

Prof. Politzer has found that in many cases the eyelet is borne without any inflammatory reaction in the drum-head or tympanic cavity ; yet, in some instances, the good result of the operation has been nullified by the irritation in the ear, consequent upon the introduction of the eyelet.

Since, in several cases in which the eyelet set up inflammation, sharp projections were found on it, Prof. Politzer urges the necessity of making the eyelet perfectly smooth before it is put into use.

Another method of retaining a permanent opening in the membrana tympani has been suggested by Voltolini,[1] of Breslau. It consists in making a long incision both in front of and behind the manubrium, and then encircling the latter with a tubular ring of fine gold. The latter is about $2\frac{1}{2}$ mm. in diameter, and is so constructed that when its two free ends are brought together on the inner side of the drum-head behind the malleus, they do not fit closely together but permit of a passage of air into the tympanum, which is further insured by an opening in the canule on the outer side. The latter opening marks the hinge-like division in the canule, and is opposite the point of junction of the free ends. Into the calibre of each half of the tube at this hinge- or joint-like point, Voltolini passes the delicate and flaring pointed ends of specially devised forceps, by which the canule is pressed into its circular shape after its free ends are brought behind the manubrium. But necrosis of the manubrium having resulted from this manipulation, it would seem that this procedure could not be of universal application when a permanent opening in the drum-head is to be obtained, though the conception of the plan must be considered brilliant.

Aluminium being of specific gravity, lighter than that of gold, has been substituted by Voltolini in the manufacture of the tubular ring.[2]

It has been proposed, by Weber-Liel,[3] to make a cicatrix in the membrana tympani, at its inferior posterior quadrant, by means of the galvano-cautery, and in the spot thus deprived of its regenerative power, to make an opening, with the hope

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[1] Monatsschrift f. Ohrenh., No. 3, 1874.

[2] See Weber-Liel, M. f. O. No. 4, 1875.

[3] Eine persistente Œffnung im Trommelfelle. Dr. Weber-Liel, M. f. O. No. 2, 1871, and No. 4, 1875. Also " Progressive Schwerhörigkeit," p. 185, 1873.

that such a perforation would persist. By this method, a perforation has been maintained for 3½ years, with the greatest improvement in the hearing.

In a number of cases of chronic otitis catarrhalis, with little or no opacity of the membrana tympani and with a pervious Eustachian tube, Simrock has resorted to puncturing the drum-head by the application of sulphuric acid, usually to a spot on the posterior half of the membrane. The method is said, by its proposer, to be not at all hazardous, as a very little acid will produce all the desired effect, and be entirely under control. The acid is applied to the desired spot by means of a tuft of cotton on the end of a probe, and an opening is effected almost instantly by gentle pressure of the probe point, or by smearing the acid carefully over the membrane at a circumscribed point; the tissue is rapidly destroyed, and the hole is cleared by lifting away the dead substance. The asserted advantages of this method are the rapidity and permanence of its effects. Of 17 orifices thus made, three remained open for four months. In three cases slight inflammation of the middle and external ear occurred, but without serious complications. Hearing for conversation improved markedly in six; less so in four; no improvement for hearing in seven. Of seventeen cases the tinnitus disappeared in five; in nine it was much diminished; in three unimproved. "After the perforation has thus been made, the ear should not be syringed even if slight discharge occur."[1]

I have never employed either of these two last-named methods, nor, in fact, any method to retain a *permanent* opening in the membrana tympani. The latter structure is emphatically a protection to the mucous lining of the drum-cavity, and rather than incur the probability of a suppuration in the middle ear by exposure, I have refrained from that which would be unlikely to prove of great help to the hearing, but which might be very apt to excite inflammation in the drum-cavity.

Tenotomy of the Tensor Tympani.—In 1868, Dr. Weber-Liel,[2] of Berlin, acting upon a suggestion of Hyrtl, invented the ope-

[1] New York Med. Record, March 27, 1875.
[2] Monatsschrift f. Ohrenh. No. 4, 1868; No. 12, 1868; No. 10, 1870; No. 11, 1871; No. 12, 1871; No. 1, 1872; No. 3, 1872. Vortrag: Berliner Medicin. Gesellschaft, 8 Juli, 1874. See Virchow's Archiv, Bd. 62.

ration of tenotomy of the tensor tympani, for which he devised a special instrument, his so-called "hook-knife."[1]

At various times since then Dr. Weber-Liel has published articles on this subject, setting forth the indications for, and the manner of this operation, together with the results of it, which he claims are in the main advantageous.

His views have met with warm support by some, but with entire opposition by others, on the other side of the Atlantic. In America the operation has been regarded with caution; a few have performed it and published their results; but on the whole, the operation has not afforded here the aid, in treatment of progressive hardness of hearing, which it appears to have done in the land of its origin.

I have had the great pleasure, as well as the privilege, of seeing Dr. Weber-Liel perform this operation, and although its performance, with the inventor's instrument, seems to have been difficult for most of those who have attempted it, Dr. Weber-Liel certainly performs the operation with ease.

The *indications* for the operation are permanent retraction of the tensor tympani muscle, indrawing of the membrana tympani and the chain of ossicles, with a consequent increased intra-labyrinthine pressure. The latter may produce, besides tinnitus and dizziness, gradual atrophic alterations in the terminal filaments of the auditory nerve. After all known methods of treatment of these symptoms had failed, Dr. Weber-Liel has had recourse to tenotomy of the tensor tympani.

The instruments requisite for the performance of this operation are: 1. The peculiar tenotome devised by Weber-Liel; 2. A short speculum; and 3. A fixation-apparatus for the head.

The operation consists in four acts:—

1. The introduction of the tenotome into the external auditory canal, and an incision, by means of the upper cutting edge of the hooked blade, through the membrana tympani, about one to one and a half mm. long, a little below and in front of the short process of the malleus.

2. Insertion of the hook-knife into the tympanum: "by a movement of the handle of the instrument downward and forward, the hook-blade, if introduced with the most accurate

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[1] Hakenmesserchen.

knowledge of the anatomical relation of the parts, glides over the tendon of the tensor, which is thus seized from in front."

Fig. 70.
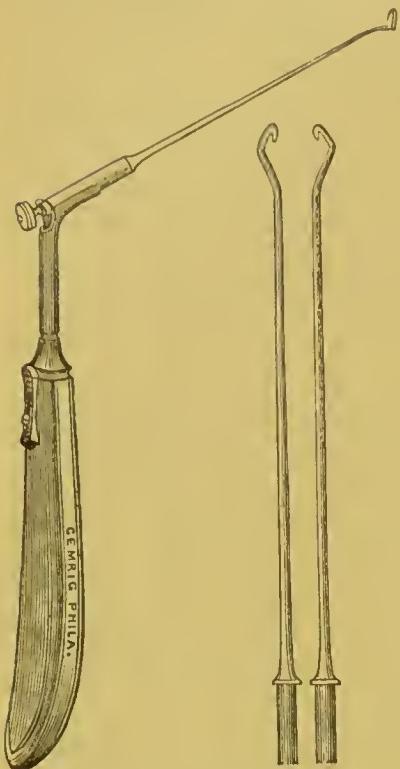
Now, the greatest care must be exercised not to wound the chorda tympani, nor yet to come too close to the inner wall of the tympanum, for fear of wounding the stapes.

3. When the hook-blade is firmly engaged over the tendon, a gentle dragging force, accompanied by a movement of the handle of the tenotome forward towards the face of the patient, and a pressure downward of the slide in the handle, will cause the blade to make a quarter of a revolution about the tendon, which is thus severed. At the moment of the latter occurrence a distinct snap is heard.

4. The operator must make every effort to keep the instrument in the front part of the drum-cavity, in order to avoid the delicate parts at the back part, and then to restore the blade to the position it occupied

WEBER-LIEL'S TENOTOME.

before pressed over the tendon, that it may be removed the more readily through the opening in the drum-head. Anæsthesia during the operation, has not been deemed necessary by Weber-Liel, as the procedure is not painful.

Dr. Carl Frank[1] was one of the first to put into practice the operation of Weber-Liel, substituting, however, a simpler knife, in which the blade, with its edge downward, was attached at an angle of 60° to the shaft. It is to be employed in those cases presenting a very limited view of the anterior half of the drum-head, on account of the excessive curvature backward of the anterior wall of the auditory canal. With this modification, however, he has found reason to rely on the operation of tenotomy of the tensor tympani, as proposed by Weber-Liel.

[1] M. f. O., Nos. 7 and 9, 1872.

Dr. R. M. Bertolet, of Philadelphia, performed the operation in sixteen cases, and published an account of the results.[1] He used the tenotome as proposed by C. Frank, making the incision in front of the short process, and obtained good results respecting the quelling of the tinnitus aurium in eight cases. It must be borne in mind, that, up to this point in the history of tenotomy of the tensor tympani, only the worst and most hopeless cases, occurring chiefly in infirmaries, had been operated on, and, therefore, Dr. Bertolet is justified in his views that the operation is an addition to operative otology and demands further development, a view which he holds in common with Gruber.

Prof. Gruber[2] has written respecting the choice of the initial incision, through the drum-head, in the operation of tenotomy of the tensor tympani. He alludes to the great services of F. E. Weber-Liel, connected with the introduction of this operation into otological surgery, and, while agreeing with him that usually the incision in the membrana tympani may be made in front of the short process of the malleus, says that this is not an invariable rule. His reasons for these views are as follows: The rostrum of the semicanalis musculi tensoris tympani varies in its position in the tympanum, being sometimes over the anterior segment of the upper arch of the oval window (or it may be over the window), and in some cases it may be over the posterior segment of the oval window. The direction of the tendon, as it passes from the rostrum cochleare to the handle of the hammer, must vary greatly according to the position of the former bony process, and accordingly the handle of the hammer, in cases of retraction, will have a variable appearance. If the rostrum cochleare is placed far backward, the hammer will appear drawn more backward and inward than if the rostrum is situate further forward, when the handle of the hammer will appear to be drawn directly inward. In the latter case the anterior segment of the membrana tympani will not appear to be as large as it does in the former case, where the handle is apparently drawn far backward and upward. Hence, Gruber concludes that no positive rule can be established respecting the choice of a point

[1] Transactions American Otol. Society, 1873.

[2] Ueber die Wahl der Einstichsstelle am Trommelfelle bei Durchschneidung der Sehne des Trommelfellspanner. Prof. J. Gruber, M. f. O., No. 4, 1873.

for incision, most likely to reach the tendon of the tensor
tympani muscle; but the variable relations in the membrana
tympani, and especially the position of the manubrium of the
malleus, must aid in deciding where the incision should be
made.

Various Tenotomes.—Prof. Gruber has devised a simple and
efficient instrument for performing tenotomy of the tensor
tympani. It consists of a simple
blade about 1 cm. long, slightly
curved at the end; by being
used in a handle in which it is
adjustable, it may be employed
for either ear. I have had the
pleasure of seeing Prof. Gruber
operate with this instrument,
upon a young peasant woman.
The well-known click as the
tendon is severed, was heard;
the membrana tympani at once
assumed a less retracted appear-
ance; the tinnitus aurium was
relieved, but the hardness of
hearing was apparently not
altered. The latter could not
be accurately tested by speech,
as no one present could speak
the peculiar Bohemian dialect,
the mother tongue of the patient.
There was no subsequent inflam-
matory reaction.

In 1873, Voltolini[1] proposed
to perform tenotomy of the
tensor tympani through the
posterior segment of the drum-
head; and in the same year, J.
Orne Green[2] published an ac-
count of his investigations into the choice of a similar point for
the initial incision. The latter authority rejects Weber-Liel's

Fig. 71.

1. Gruber's Tenotome and adjustable
handle. 2. Gruber's Tenotome. 3. J. O.
Green's Tenotome. 4, 5. Two views of
Hartmann's Tenotome.

[1] M. f. O., No. 5, 1873.
[2] Trans. Amer. Otol. Soc., vol. i. p. 401, 1873.
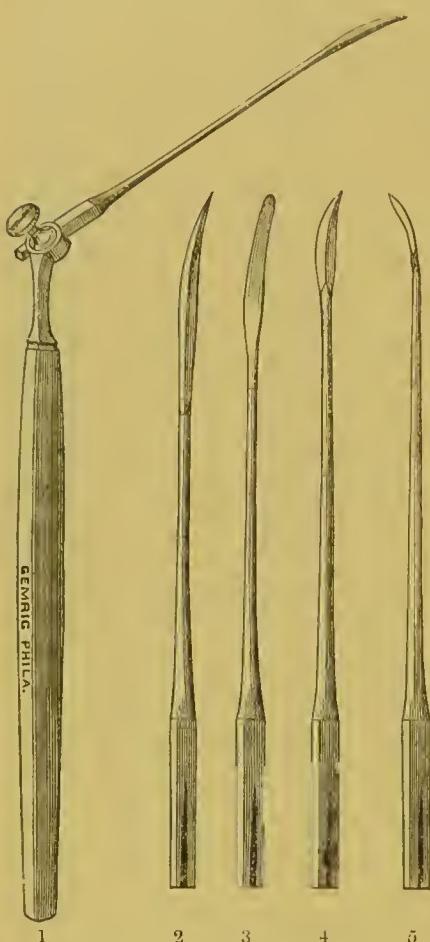
operation entirely, and, not being entirely satisfied with Gruber's operation through the anterior segment of the drum-head, has resorted to section through the posterior segment, between the manubrium and the long process of the incus. This is done by reversing Gruber's knife, turning the curve forwards, when the tendon can be easily and surely reached; but as this knife is sharp-pointed, Dr. Green used a knife of his own invention, rounded at the end and with curved edges (Fig. 71, 3). With this, Dr. Green has been enabled, in every case, to divide the muscle a short distance from its exit from the osseous canal, and in no case were the ossicula even touched. The danger of wounding the carotid artery in those exceptional cases where its osseous canal is very thin or entirely wanting is, in Dr. Green's opinion, obviated in great measure by having the end of the knife round instead of pointed.

Dr. O. D. Pomeroy,[1] of New York, has corroborated, in the main, the views of Gruber and Green respecting this operation as performed by the posterior method. He prefers, however, to enter the tympanum near the end of the manubrium, and then, cutting upward until the tendon is reached, to divide the latter by an up-and-down movement. While tinnitus has been relieved greatly in some cases, the hearing has not been much improved.

As recently as 20th September, 1875,[2] Weber-Liel, in speaking of the practical results of this operation, stated that he had performed it in more than 300 cases. He insists on the necessity of the greatest previous practice on the cadaver, before the operation is attempted on the living subject. He rejects the assertions that the operation is in any way dangerous to life or detrimental to the amount of hearing still existing anterior to the operation. The best result of the operation, he thinks, has been the quelling of the tinnitus aurium; greater benefit to hearing would accrue if the tendon were cut at a much earlier stage than heretofore deemed necessary. Some of the most brilliant results have been nullified at last by a want of care of the ear, on the part of the patients, subsequent to the tenotomy.

In the discussion which ensued, Dr. Kessel drew attention to

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[1] Transactions American Otol. Soc. 1874.
[2] 48 Versammlung Deutscher Naturforscher und Aertze in Gratz.

the important fact that an attempt should always be made, before
the operation was performed, to find out the condition of Corti's
organ, especially whether speech (C^2–C^5 of the musical scale)
were perceived. If this were not heard, then in his opinion the
operation should not be attempted; a view apparently not to be
received in its entirety, if the operation is specially able to
relieve tinnitus aurium, an ill more complained of sometimes
than deafness.

Prof. Gruber took the ground that the one great indication
for the operation was shortening of the tendon and a consequent
indrawing of the membrana tympani, of the chain of ossicles,
and the increase of the intra-labyrinthine pressure, and that it
is not necessary to wait until all further indications are known
and explained. In the same discussion Magnus stated that to
him the indications so far given by Weber-Liel were not suffi-
ciently clear, as synechial adhesions, synostosis of the stapes
in the oval window, thickening of the membrane of the round
window and changes in the tympanum, other than shortening
of the tensor tympani, might account for retraction of the drum-
head.

Prof. Schwartze[1] has performed the operation of tenotomy of
the tensor tympani by means of a simple and efficient tenotome
not unlike that of Gruber and Green in its principle.

He has not found fixation of the head nor anæstheties neces-
sary; the point of initial incision, made by means of a paracen-
tesis needle, has been behind the upper end of the manubrium
and the short process; the cutting of the tendon has been
accomplished by sawing movements and not by a solitary act of
cutting. Immediately after the severance of the tendon, if the
membrana tympani is not too thick, an effusion of blood can be
seen in the tympanum. Among all the cases operated on by
Schwartze, there has not been one permanently benefited; but
none have been harmed.

While indisposed to accord a future to the operation of teno-
tomy of the tensor tympani, so far as total severance is con-
cerned, Schwartze agrees with Von Troeltsch, who has suggested
a partial loosening of the tendon from its insertion on the
malleus, that the latter modification may have a beneficial effect.

[1] Zur Tenotomie des Tensor Tympani. A. f. O., B. xi. p. 124, 1876.

Such a partial loosening, as it corresponds to the alteration of insertion, as in Von Graefe's operation for squint, should be attempted by operating from below upward, in which instance the introduction of the tenotome from in front of the malleus would be preferable.

Dr. Arthur Hartmann,[1] of Berlin, who has worked in company with Prof. Politzer, of Vienna, has found it advantageous to use a tenotome with two curves (Fig. 71, 4 and 5), one upward on its cutting edge, the other forward, on its flat surface. This gives a sabre-like form to the instrument, by which means it appears that the stapes and the chorda tympani are fully insured against injury. While apparently successful in making the severance of the tendon, Dr. Hartmann concludes that the result of tenotomy of the tensor tympani can never be fully established, until all other elements entering into the operation can be excluded from participation in any apparent good which may accrue. Thus, in one instance, before the tendon was severed, the posterior fold of the membrane was cut, and the tinnitus aurium was greatly relieved; but the subsequent tenotomy produced no further relief.

I feel great reserve in giving an opinion derived from personal experience respecting the operation of tenotomy of the tensor tympani, as I have performed it but once on the living. The result, so far as I could discern, appeared to be null; perhaps I failed to sever the tendon. It has appeared to me, therefore, that whatever I should record here respecting this operation should be gleaned from those who have performed it frequently. Another reason why these authors should have almost a detailed notice is because they are in the minority. I also have borne in mind, as all must, that theory usually comes after practice, in the introduction of all new procedures in surgery. It is right that a new invention should gain admission to the list of acknowledged operations, only after a struggle and a thorough test of its merits. No fair-minded man dare reject this operation in a summary manner; neither dare he accept, apply, and vaunt it unless his knowledge of the anatomy of the middle ear be accurate, his preparative operations on the cadaver

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[1] Ueber die Operations Methoden der Tenotomie des Tensor Tympani. A. f. O., B. xi. p. 127, 1876.

thorough and numerous, and his experience in results on the
living, rich and beyond cavil.

*Removal of Fluid and Inspissated Matter from the Cavity of the
Drum and Eustachian Tube.*—Before inflation of the tympanum
provided the surgeon with an efficient and harmless method
of clearing the Eustachian tube, it was customary to inject bland
fluids into the tube. The stream thus forced into the middle
ear was found to be most efficient when it could escape by the
external auditory canal.[1]

Mr. James Hinton, of London, believed that mucus often
became hardened in the tympanic cavity, behind an intact
drum-head, and, giving to the latter a white, opaque appear-
ance, led to a diagnosis of thickening of the membrana tympani.

To obviate the deafness in such cases, he made an incision
2–3 lines long in the drum-head, behind the malleus, and then
forcibly injected, from the external auditory canal, a warm solu-
tion of bicarbonate of soda. He laid great stress on the herme-
tical fitting of the nozzle of the syringe into the meatus. I
have never found this procedure necessary in this country, where
I believe inspissation of mucus is less likely to occur than in
more humid and colder climates. It is not uncommon in
syringing an ear affected with chronic discharge, to find that
the water passes into the nares.

This is no disadvantage if it is produced by gentle syringing,
but forcible syringing in any case in which there is an opening
in the membrana tympani, must be regarded with caution, since
a force thus applied with a view of carrying matter through the
Eustachian tube into the pharynx might force some of the
injected fluid into the mastoid cavities and set up irritation
there.

Accumulation of fluid in the tympanic cavity and the best
means for its removal are illustrated in the following cases:—

Case I. *Brownish Transparent Fluid in the Tympanic Cavity,
visible only through a thin depressed Cicatrix; Incision and total
Relief.*—Dec. 1, 1875, Dr. A., 80 years old, a hale, hearty man,
single. Has an extraordinarily well-preserved constitution.
Patient states that for a month, since a cold in his head, he has
noted a failure of hearing in the right ear. He is liable to accu-
mulations of ear-wax, according to his statement, and has had

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[1] Rau, op. cit., section 210.

his ear syringed, on the supposition that the deafness was due to inspissated cerumen. But no relief was thus obtained. On examination of the ear, the membrana tympani appeared rather opaque, excepting at the upper and hinder quadrant, where it was thin and depressed, and through which the incudo-stapedial joint was plainly visible. This thin, depressed quadrant was markedly of a dark brownish-yellow color; the rest of the membrane was opaque and gray. Under Siglé's pneumatic speculum, it swelled out into a bladder-like protuberance, and seemed to be filled from behind with a dark yellowish-brown fluid, as the air was exhausted by the speculum from the auditory canal. The hearing was about a foot for voice and $\frac{1}{50}$ for watch. The tympanum could not be inflated by any method, as the Eustachian tube was markedly occluded by the remnants of the catarrh. The patient also stated that the Eustachian tubes were never easily inflated by Valsalva's method; in fact, he doubted whether they were of the average width. No form of inflation caused any alteration in the appearance of the depressed spot, which moved so easily under the Siglé speculum. Incision of this spot gave instant escape to some brownish transparent serum or mucus, and suction with the Siglé speculum brought out a good deal more, in all about twenty to thirty drops. The hearing immediately arose to about the normal grade. Voice and watch were heard easily 30 feet. In the course of a week, as was to be expected from the swollen state of the Eustachian tube, the tympanic cavity filled again. Paracentesis of the same thin spot gave vent to about the same quantity of fluid, and the hearing again went up. In the course of another week, a slight return of "muffled feeling" in the ear, which was relieved by incision and escape of a small amount of fluid. At this visit the Politzer bag forced the Eustachian tube open, and there was no further return of deafness. On March 30, following, I examined the membrana tympani, and found that the thicker part was more shining, and the thin spot, though depressed, was not discolored by any brownish fluid in the drum-cavity. Hearing normal.

CASE II. *Re-accumulation of Mucus in the Tympanum.*—July 1, 1874, Jacob Y., aged 55 years, single, American, furnace-maker, a healthy, spare man. Not very strong. Seems to be a man of more than ordinary intelligence for one in his position. He

states that for a year or more past, he has noted a gradual dimi-
nution of hearing on the left side. The right meatus auditorius
is occluded as described on page 320, on which side the tuning-
fork, when vibrating on his vertex, is best perceived. The case
has been treated by several physicians as one of ordinary chronic
catarrh of the middle ear. The drum-head has been said to be
thickened, the catheter has been used to inflate the tympanic
cavity and to convey various fluids into the Eustachian tube.
This treatment, he says, always produced a temporary improve-
ment in the hearing.

When I examined the ear, the membrana tympani appeared
thickened, and resembled in general the opaque lustreless drum-
head of chronic catarrh. The hearing for the watch was about
$\frac{4 \text{ in.}}{60 \text{ in.}}$. I also inflated the middle ear by means of the catheter,
several times a week for a month. Each inflation improved the
hearing a little, but in a few hours it sank back again to its low
point. The inflations were repeated from time to time for a
few weeks longer, with always some improvement in hearing.

On the 12th of September, the patient came with the state-
ment that the benefit of the catheter, though marked, was only
temporary; that he constantly felt something like a drop of
fluid moving in his ear whenever his head was moved, and that
whenever he lay down he heard better. He had told me this
before, but I paid no heed to it. But it was now discovered
that when he reclined, the hearing really became better, as was
shown by testing with a watch. This seemed to point to mov-
able fluid in the drum-cavity, and consequently it was proposed
to the patient that the drum-head should be incised. This being
acceded to by the patient, a puncture was made in the posterior
inferior quadrant of the membrana tympani, and there instantly
escaped, on inflating by Valsalva's method, about twenty drops
of a brownish, transparent, serous fluid, with some streaks of
opaque mucus. But its presence had been in no way, as far as
I could discover, indicated by any appearance of the membrana
tympani. The hearing arose from one inch to five feet for a
watch. The membrana tympani became more concave, and of
a bluer hue; before the incision it was flat and steel-gray. The
hearing, thus regained, remained unimpaired until March, 1875,
when, after catching a cold, the symptoms returned in the ear.
In this instance there was rather a sense of fulness than of

movable fluid. A paracentesis in the same spot restored the hearing, by giving vent again to a similar thinnish fluid, nearly transparent, and tinged with brown.

By the 23d of same month the ear filled up again. The membrane was again perforated, as it resembled the membrana tympani in the previous conditions; though I do not pretend to say that a dark-grayish color of the drum-head indicates mucus or serum in the tympanic cavity. The perforation gave vent to the same kind of brownish fluid, strongly suggestive of extravasated serum from the capillaries of the tympanum. The hearing instantly arose to its relatively normal point.

By the 15th of April following, the same symptoms of muffled hearing returned, and the membrana tympani seemed flattened somewhat, but not enough to attract the attention of one entirely unacquainted with the case, and not on the lookout for changes in the membrane. The color of the drum-head might be said to be dark gray. After the incision it always assumed a light bluish-gray color. Again the paracentesis of the drumhead was resorted to, and after the *usual* brownish-red fluid escaped, the hearing returned.

Again, on May 8, the same note is made, and again on June 8. Then perfect immunity from aural trouble until Sept. 8, when the symptoms returned, but relief was obtained as above. Again, on October 26 and November 24, the membrana tympani was punctured, which completed the history for 1875. On January 3, 1876, the hearing had become again dulled, the condition being soon recognized by the patient, who came to have his ear operated on again.

The incision was made with just the same results as above, and then again on Feb. 19, and on March 28.

Only once, February 19, were bubbles in the tympanum, behind the membrane, visible through the latter. On Valsalva's inflation they moved very markedly. The amount discharged in this instance was less than on previous occasions. In every other instance there was nothing to call special attention to the presence of fluid in the drum; and this circumstance leads one to believe that many such cases are treated as chronic catarrh, and regarded as gradual sclerosis of the tympanum, because there is no special change on the drum-head indicative of fluid in the tympanic cavity. As the fluid gradually gets

harder, the case is abandoned as hopeless. This would seem
to be avoidable in some cases, judging from this and others, by
incising the membrane, at least as a last resort, even when the
case resembles those of so-called dry catarrh, with thickening
of the tissues of the tympanum.

The operation never caused the slightest pain, the perforation
always healed within twenty-four hours, and the relief gained
by the evacuation of the fluid contents of the tympanum lasted,
in each instance, for a month at least and sometimes longer.
In only one instance could bubbles be seen in the tympanum
before the membrana tympani was incised, viz.: on the 19th
Feb. 1876.

The case never presented, on any other occasion, the ordinary
signs of mucus in the tympanum. In fact, the paracentesis in
the first instance was performed solely on the strength of the
subjective feelings of moving fluid in the drum-cavity.

The point the case just narrated illustrates is, the great pro-
bability that many a case of chronic deafness is only due to
retained mucus in the cavity of the drum, the symptoms of
which have not been, and cannot always be, clearly defined,
for they may not be at all sharply expressed on the drum-head.

Where this fluid came from, and what caused its constant
recurrence, are not easily answered. The Eustachian tube was
always pervious to Valsalvan inflation, and to the air of the
catheter, Politzer's bag, etc.

There was no faucial or nasal catarrh, nor any intercurrent
nor chronic disease. The patient enjoyed, throughout the ob-
servance of the case, good health, and a life of comparative ease,
for he did not work constantly at his trade, being supported
otherwise.

The difficulty of diagnosing the presence of fluid or even in-
spissated mucus in the tympanum, in these cases of chronic
catarrh, depends on several causes. The chief obstacle is of
course the more or less altered condition of the membrana tym-
pani. This may be so uniformly thick as to prevent seeing the
delicate outlines of bits of mucus or bubbles lying against its
inner surface. If it is cicatrized at any point, the retained fluid
will cause a bulging at the cicatrix almost invariably, but, if the
membrane is uniformly thick, the mucus cannot make it bulge
at any one point.

Fluids in the tympanic cavity will also discolor a thin cicatrix, but they do not alter the color of a thick membrana tympani enough to acquaint the observer with the state of the tympanic cavity. And just here the diagnosis has usually stopped. It has been correct in determining a thick state of the drum-head from chronic catarrh; but just this state of the membrane has prevented a further judgment as to the tympanic condition and contents. This same thickening and consequent rigidity has prevented anything in the way of marked protuberance or bulging of the membrane. Its position is not in such cases altered enough to aid in diagnosing any obstructive mass behind it. The only aid in such a case is to observe the other membrana tympani and compare the two. If one ear is worse than the other, and the worse ear presents a membrana tympani flatter, *i. e.* less concave inwardly and on the whole more protuberant, than the better ear, a conclusion might then be drawn in favor of the view that retained mucus is behind the drum-head, which thus projects *relatively.*

Mr. Hinton states that in some instances of retained and inspissated mucus in the tympanum, the membrana tympani may be abnormally retracted. This of course is due to the partial vacuum in the drum-cavity.

ELECTRICITY IN AURAL DISEASES.

In 1868, Dr. Rudolph Brenner, of St. Petersburg, published his renowned work on Electro-otiatrics. His book consisted of a series of investigations and observations respecting the operation of electric currents upon the organ of hearing, both in health and in disease. It was avowedly an endeavor to found a rational electro-otology.

For seventy years previous to this time, *i. e.* from the time of Volta, and his zealous pupil Ritter, numerous experiments had been made to find out whether and how the auditory nerve reacted under electric stimulation; but, as Brenner says, this period closed without any definite knowledge on this point. In the historical sketch, which precedes the account of Brenner's labors, the reader is informed that the first experiments were performed in 1800–1802 by Volta and Ritter; afterwards by Grapengiesser, who apparently was the first to produce sensation

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of sound by means of a simple current. From this time the entire subject remained untouched until Erman, in 1812, revived it. A long pause in this kind of work then ensued, until once more the subject was resumed by R. Wagner in 1843, who stated that it was extremely difficult to produce sound-sensations in the ear by means of galvanism. Then followed the testimonies of E. H. Weber, 1846, E. Harless, 1853, and Longet, 1850, that sound-sensations could be produced in the ear by means of the electric current.

Schiff, 1858, Ludwig, 1858, and Fick, 1860, appear to be in doubt whether the nerve is really electrically excited in these cases in which sound-sensation appears to be produced ; they incline to the view that it is due to purely mechanical excitation of the sound-conducting parts, as did E. H. Weber.

Dr. Brenner has usually employed in his experiments a zinc-copper battery, but he has also used zinc-carbon batteries. The first, especially the Siemen's modification of Daniel's battery, is preferable on account of its more constant stream and slow exhaustion. Twenty of the above-named cells will be sufficient for all purposes connected with the application of electricity to the ear.

Mode of Application of Electricity to the Organ of Hearing ; Instruments employed.—The electrodes are connected to the ear by means of wires inclosed in rubber tubing. They should be from six to ten feet long, in order to allow of perfect freedom in movement, change of position, and varying distances between battery and patient. The electrodes may vary in pattern : small ball-shaped ones, covered with thick muslin, which can be wet with salt and water, are preferable when the electrode is to be simply placed in the meatus, unfilled with water. The form of electrode for the ear, used chiefly by Brenner, consists of an ordinary hard rubber ear-funnel, to which is fastened copper wire extending down the long axis of the funnel. This form is to be used in the auditory canal filled with tepid water.

The number of elements to be inserted into the current is decided by means of what is called a polarity chooser (Strom-wähler), the current is turned by a polarity changer (Strom-wender), and its rapidity, *i. e.* intensity, is lessened by a rheostat or resister. Inserted into the current may be a magnetic needle, which will always give information to the surgeon, respecting

the activity of the current. After ten years of most careful observation, Dr. Brenner has become convinced that the auditory nerve can be excited by the electric fluid, and he has announced the following formula for describing the phenomena which occur during such galvanic excitation.

Brenner's Normal Formula of the Reaction of the Auditory Nerve. —The signs used in this formula are: G (Geräusch, noise), to designate the acoustic sensation excited by the galvanic current; the degrees of intensity, by G′ and g; closing the current by S (Schliessung); duration of the current, D (Dauer); and the opening of the same by O (Oeffnung). The direction is indicated by the name of the electrode in the ear at each moment of separate excitation, *i. e.* the kathode by Ka, and anode by A. Then the phenomena occurring by galvanic excitation of the auditory nerve may be expressed thus:—

Ka S G′: means that a marked sensation of sound occurs at each closure of the current, while the organ of hearing is under the influence of the kathode and the anode is placed upon a spot of the body at a distance from the ear.

Ka D G >: means that a sound is heard, which rapidly diminishes and finally ceases, while the current runs in the same direction.

Ka O—: When the current is opened no sound sensation is perceived.

A S—: If, now, the current be turned, so that the organ of hearing come under the influence of the anode, there occurs no sensation of sound by closing the current.

A D—: Nor does such occur during the continuance of the current.

A O G: But by opening the current, sound sensation occurs, which corresponds qualitatively with that which was perceived when the current was closed while running in the opposite direction. But this sensation is much slighter and only of momentary duration.[1]

There may be several deviations from this normal formula in certain pathological conditions of the auditory nerve. Dr. Brenner gives the following:—

1. Simple hyperæsthesia: An auditory nerve thus affected,

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[1] Brenner; Electro-Otiatrik, p. 91.

reacts under electric currents very much weaker than those required to produce a corresponding excitation in the normal auditory nerve. Thus the duration (D) of the reaction during the moments Ka D and A O is much longer, and during a moderate current the Ka D-sensation does not terminate before the opening of the current.[1]

2. Hyperæsthesia with qualitative alteration of the formula: In this state the reaction of the auditory nerve under the electric excitation manifests not only an easy excitability, but also a change in its mode of occurrence. Thus, with Ka S, Ka D, and A O there is a subjective ringing, and with A S, A D, and Ka O there is hissing.[2]

3. Inversion of the formula for simple hyperæsthesia: In some cases the disappearance of the normal formula in presence of the pathological, can be very striking. The former may be characterized by the lower notes of the scale, and distinguished from the pathological reactions by shortness of duration. With weak currents this condition does not manifest itself.

4. Hyperæsthesia of the auditory nerve with the paradoxical formula in the unarmed ear.

This form of hyperæsthesia is very curious and very frequent, and has been observed by Brenner only in old and deep disease of the ear.

This form is characterized by the circumstance that during the application of electricity to one ear, not only the auditory nerve of that side but also that of the other ear responds, but in an inverted manner, so that in the ear not under treatment the perceptions of sound occur at those moments of excitation, during which the nerve of the ear immediately under treatment is silent; the ear not treated reacts exactly as if it were under the influence of the other electrode.[3]

The observations and formula of Brenner have been fully verified by Erb,[4] Moos,[5] and Hagen,[6] in Germany, and by Blake and others in this country.

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[1] Op. cit., p. 183.   [2] Op. cit., p. 195.

[3] Brenner, op. cit., p. 201.

[4] W. Erb, Die galvanische Reaction des nervösen Gehörapparates, etc. Archiv f. Aug. und Ohrenheilk., Band i. p. 156, and Band ii. pp. 1–51.

[5] Klinik der Ohrenkrankheiten, 1866, p. 332, and elsewhere.

[6] Electro-otiatrische Studien. Wiener Med. Wochenschrift, 1866.

Schwartze,[1] Shulz,[2] and Benedikt,[3] have been the principal opponents of the views of Brenner. The present status of the question may be said to be as follows: Brenner and his co-laborers believe that they have demonstrated that the subjective sound-sensations occurring during a galvanic examination of the ear, are produced by direct stimulation of the auditory nerve. The opponents above named, strong men in science, believe that these sensations depend upon reflex irritation of the trigeminus and the sympathetic nerve. It appears, however, that the burden of proof still lies with the latter party.

A somewhat new field of therapeutic application of the constant electric current has been opened by Dr. Weber-Liel, of Berlin. This observer introduces the current through the Eustachian tube by means of a silver wire conveyed through a catheter.[4] By this method he claims to bring the muscular structures of the tube and perhaps those of the middle ear (tensor tympani and stapedius) under the direct influence of the galvanic current. It will be seen that in such an application of electricity, the direct irritation of the auditory nerve is left out of consideration. The treatment is really applied to the middle ear, and probably marks a new era in the use of electricity in some forms of aural disease, as for example, in cases of atrophy, flaccidity, or degeneration of the muscles. In such cases perhaps the muscular structures of the middle ear derive a benefit from the gymnastic, as well as from the dynamic effect of the electric current.

It is claimed by Weber-Liel that this kind of intra-tubal electrization will relieve the symptoms of paralysis in the tubal muscles, cause the subjective noises to cease, and bring the hearing almost to the normal standard, if the treatment is begun before secondary changes have occurred in the tympanum, and if no other complication exists. He also states that after the tubal muscles have been thus galvanized, the air from the catheter can be forced into the tympanum more readily, without the aid of swallowing, the latter is more easily performed and in-

[1] Archiv f. Ohrenh., Band 1.

[2] Sitzung der k. k. Gesellschaft d. Aertze, 2 July, 1865, also Wiener Med. Zeitung, 1865, No. 23.

[3] Wiener Med. Presse, 1870, Nos. 37, 39, 42, 43, 47, 48, 50, 51, and 52.

[4] Progressive Schwerhörigkeit, p. 36.

flation by Valsalva's method succeeds where before it failed, all of which he adduces as proof that the paralysis of the muscles concerned in these acts has disappeared, and that the disappearance is due to the use of electricity.[1]

But the latter part of the proposition cannot be so easily admitted, since exactly the same improvement in these parts does occur after a careful catheterization, and the use of a bougie passed up into and even past the isthmus tubæ.

Not only in recent but in chronic cases of catarrhal disease, and closure of the tube, in which neither by the catheter, Valsalva's method, nor by the act of swallowing, the tube could be opened, a bougie passed into the tube on two or three successive days, has appeared to stimulate the tubal muscles to proper action, without the aid of electricity.

To illustrate this let me bring forward the following case: Mr. T., 40 years old, of Maine, consulted me with his physician, for deafness in the right ear, following a copious and chronic naso-pharyngeal catarrh. The active catarrhal symptoms had been checked, and the mucous membrane of the nares and pharynx was abnormally dry. The right membrane was thin; promontory and incudo-stapedial joint visible through the membrane; lustre good. Great tinnitus, hearing for watch $\frac{0}{60}$ in. At the first visit, air could not be forced into the tympanum by the catheter nor by the Politzer bag. A silver catheter was then introduced, and through it one of Weber-Liel's admirable tympanic catheters (delicate flexible bougie-catheters of gummed silk) was pushed through the silver instrument and into the tympanum. This produced an immediate though slight improvement in hearing; but the operation was repeated on three consecutive days, and by the fifth day after the first operation the patient volunteered the statement that "his ear opened whenever he swallowed, a sensation he had not noticed for nearly a year." Air could now be forced into the tympanum both by the catheter and Politzer's method. The hearing arose to $\frac{5 \text{ in.}}{60 \text{ in.}}$ for the watch, but the tinnitus was not materially altered. The patient, being obliged to leave the city, passed from under my treatment.

The case is quoted chiefly to prove that the signs of muscular

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[1] Op. cit., p. 165.

paralysis may be made to disappear without the aid of electricity.

Since in this case, and in many similar ones, the physical manipulation of the diseased parts is almost identical with that adopted by Weber-Liel in his intra-tubal electrization, excepting that the latter factor, the passage of the electric current, is left out, and since the result is about the same in both instances, it would really seem that the benefit in such cases depends upon a thorough opening of an occluded Eustachian tube, and the consequent restoration of the tympanum to a proper degree of ventilation, and *not upon electricity.*

Dr. Hitzig[1] prefers the so-called external application of electricity for therapeutical purposes. But he thinks that the electrization of the muscles in the tympanum, by means of the electrode (wire) introduced into the Eustachian tube, may in the future be shown to be of value, but for the direct excitation of the acoustic nerve this method has but a limited supplemental worth.

CHAPTER IV.

UNUSUAL DISEASES OF THE MIDDLE EAR.

It is proposed to devote this chapter to the consideration of several rare and interesting pathological processes, in the middle ear. Some of these about to be described have been observed in close connection with catarrhal processes in the tympanum, and some of them may have had their origin in such a process in the tympanic cavity. They are certainly full of interest to the aurist, and not without interest to the general practitioner. As these diseases are rare, and some of them malignant, it must be accepted beforehand that the treatment is an open question in some, and unsatisfactory in others. One of the rarest and most interesting is that first described.

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[1] Bemerkungen über die Aufgaben der " Electro-Otiatrik" und den Weg zu deren Lösung. E. Hitzig. A. f. O., N. F. B. 2, p. 70.

Objective Snapping Noises in the Ear.—Sometimes there occurs a snapping or cracking noise in the ear, which is audible not only to the sufferer but to his attendants and friends. This noise has been likened to the snapping of the finger-nails, or to the sudden drawing apart of the finger-ends when slightly moistened with saliva or a tenacious fluid. The first simile is the more striking. Some persons possess the power of voluntarily producing such a sound in the ear. It is known that Fabricius ab Aquapendente and Johannes Muller,[1] were able to produce such a sound; the former only on both sides at the same time, but the latter in either ear according to his desire. It was ascribed by him to a voluntary contraction of the tensor tympani muscle. Muller[2] was disposed to regard this voluntary power as not uncommon, and mentions the fact that Meyer had known a gentleman who possessed it.

Lucæ[3] has observed this power to voluntarily produce a snapping noise in the ear, or to contract the tensor tympani, as he believes, in three friends, all of them scientific men. Politzer[4] observed both the voluntary and involuntary production of this snapping noise, in the ear of a young physician, and Schwartze[5] alludes to the voluntary ability to make this peculiar noise, as do Schrapinger[6] and Delstanche, fils.[7] I have observed on several occasions this power in certain individuals, all of them affected with an aural disease. Two of them were physicians, and with the noise, which was rather a creaking or a whizzing than a snapping, visible motion occurred in the membrana tympani. In one it was heard on both sides, and cicatrices in the membranes were seen to move most distinctly, and also seemed to contribute to the noise by a kind of crackling sound. In the second case the noise was not very loud, but the membrana tympani moved visibly. The third instance was in a patient, a young man twenty-three years old. The hearing was normal in the ear in which the noise was made. Instances of the *in-*

[1] Manual of Physiology, London, 1838–1842. Translated by Wm. Baly, M.D., p. 1262, vol. ii.

[2] Loc. cit.

[3] Archiv f. Ohrenheilk., Bd. iii. p. 201, 1867.

[4] Ibid., Bd. iv. pp. 19–29, 1868.   [5] Ibid., Bd. vi. p. 228, 1870.

[6] Transactions of the Austrian Acad. of Sciences, vol. 62, sec. 2, 1870.

[7] Etude sur le Bourdonnement de l'Oreille; Paris et Bruxelles, 1872, p. 47.

voluntary occurrence of a snapping sound in and from the ear have been observed by Schwartze,[1] Boeck,[2] Politzer,[3] Leudet,[4] Küpper,[5] and myself. Dr. R. M. Bertolet, of Philadelphia, has informed me that he has observed a case of this character, but as he saw the man but once, he was unable to make as full an examination as he desired, and therefore he has never published an account of the case.

An objective whizzing sound may come from the ear during mastication, as observed by Moos, but this is not to be classed with the distinct involuntary spasmodic snapping sounds in the ear, which may be heard objectively in some rare instances.

There are, however, several cases on record in which such a peculiar objective noise in the ear has occurred without any act of volition on the part of the patients. The noise is often very frequent, loud, and distressing in its occurrence, which presents interesting and varied features enough to warrant it a separate mention here.

Since the time of Müller's observations on himself, this peculiar snapping noise in the ear has been variously ascribed to either voluntary or involuntary contraction of the tensor tympani, to clonic spasm in the stapedius muscle, in a single case, by Wreden, or to spasm in the palatal muscles whereby the anterior wall of the mouth of the Eustachian tube is suddenly drawn away from the posterior wall and the noise is thus produced. The latter view is that of Politzer and Lushka and is now received as sufficiently explanatory of the majority of the cases which have been observed. According to this theory the noise is really produced in the naso-pharynx, but is conveyed to the ear of the subject through the Eustachian tube. The ear of an observer also perceives the noise as coming from the ear of the person in whom the peculiar sound originates. The noise is also heard equally well at the nostril of the patient in many cases.

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[1] Archiv f. Ohrenheilkunde, Bd. ii. p. 5, 1867 ; also Ibid., Bd. vi. p. 228, 1870.
[2] Ibid., Bd. ii. p. 203, 1867.
[3] Ibid., Bd. iv. pp. 19–29, 1868 ; also Wiener Med. Presse, 1871.
[1] Gazette Médicale de Paris, Nos. 32, 35, 1869 ; Comptes rendus de l'Academie de Science de Paris, May 10, 1869.
[5] Archiv für Ohrenheilkunde, Bd. i. N. F. 1873, p. 296.
[5] Philadelphia Medical Times, Nos. 172 and 181, 1875.

The case of spasm of the stapedius muscle described by Wreden is, so far as I know, unique, unless a very low and gentle tapping sound which I once heard in the ear of a patient, by placing my ear close to his, was to be explained by an involuntary twitching of the stapedius. There was nothing but its faintness that led me to this conclusion. There was no dizziness nor deafness. The cases of Leudet and Delstanche are considered by them as examples of an objective snapping noise in the ear, due to spasm of the tensor tympani muscle. That of the former was involuntary, while that of the latter was voluntary. But the account of Leudet is evidently one of this peculiar noise produced by the spasmodic opening of the mouth of the Eustachian tube; as indeed was that of Delstanche, for in both there is history of simultaneous movement in the palate.

Simultaneous Spasm in the Soft Palate.—In the vast majority of all the cases on record, this noise, whether voluntary or not, has been accompanied by a spasmodic elevation and retraction of the soft palate, and sometimes of other muscles of deglutition. In the case observed by Küpper, there was, in addition to the movements in the velum, a simultaneous elevation of the larynx, the floor of the mouth, and the root of the tongue.

Simultaneous movements, *i. e.*, retractions of the membrana tympani, have been observed less frequently than the above-named motions in the velum. The indrawing of the membrane, when observed, has not always been at the same spot. It has varied from being at the point of the manubrium, to being at various other portions of the membrane. This would seem to militate against the theory that the noise, and consequently the retraction of the drum-head, is due to spasm of the tensor tympani muscle. For were it due to the latter, the indrawing of the membrane would be likely to occur in a line with the handle of the malleus, and not in one of the quadrants of the membrane, at some distance from the malleus, as it did in the case I have observed.

Simultaneous Twitchings Elsewhere.—In some instances the involuntary objective noise in the ear has been accompanied by simultaneous twitchings of the muscles of the brow, nose, and face, as in Küpper's case, which was ambilateral, or with simultaneous spasms of the mylohyoid muscle, of the anterior belly

of the digastric, and in the brow on the same side, as was noted by Leudet. In the latter case there was neuralgia in the brow and amyosthenia of the fingers, on the side corresponding with the ear in which the noise was heard.

The age of those thus affected varies from five to fifty years, as shown in the cases reported by Schwartze. Of all those in whom such an objective aural noise, either voluntary or involuntary, has been observed, only three were females; two of whom were adults, the cases of Moos and Leudet; while a third was a little girl five years old, one of the cases observed by Schwartze.

Involuntary objective noises in the ear, and the attendant symptoms already described, rarely occur on more than one side at a time; in three instances, however, they were observed to be in both ears, twice by Schwartze and once by Küpper.

The mode of the occurrence of the involuntary snappings in the ear varies greatly. It may be too rapid to be counted (Schwartze), or isochronous with the pulse, and so loud as to waken the patient at night (Boeck), or it may resemble the ticking of a watch, with pauses (Schwartze). In the case observed by Leudet, the noises occurred in pairs, the one being a " kind of echo" of the other, and in the case cited by Küpper, they occurred irregularly, and as often as 140 times in a minute.

The state of the hearing in an ear thus affected varies with the cases, being in some, normal; in others, noises occur in an ear already somewhat hard of hearing, while in some the hearing is momentarily affected, apparently by the altered tension which ensues in the tympanum, with each spasmodic occurrence of the noise.

The following is a short account of the above-named curious affection, occurring in a Japanese lad eighteen years old, sent to me by Dr. R. M. Girvin, of West Philadelphia. The patient came under my care for treatment of a chronic suppurative inflammation of the left middle ear, with perforation of the membrana tympani, the result of acute inflammation incurred in July, 1874, by diving in cold salt water. The patient complained only of the left ear. He did not draw my attention to the right ear, affected by the spasm about to be described, but while inspecting the right ear for purposes of comparison, I heard distinctly a noise resembling the snapping of the finger-nails, emanating from it. The snapping was most audible when the ear of the

listener was placed close to the right ear of the patient, but it could be distinctly heard ten feet from the ear from which it came. It was also heard very distinctly when the ear was placed near the right nostril of the patient. It was not, however, audible in the left ear of the patient, neither by placing my ear on his ear, nor by the use of the auscultation-tube. Inspection revealed a thickened and reddened condition of the right membrana tympani; and the patient stated that he had had, some years previous, discharges from the right ear, and it was found that the hearing was defective in it.

The snapping sounds began in it in the previous summer, one week after the acute inflammation in the left ear. At the first examination, by simple inspection, no motion was detected in the membrana tympani at each snapping, but in the course of a month, the thickening of the drum-head becoming less, a very slight retraction of the drum-head at its antero-superior quadrant was seen. Before any motion in the drum-head was observed by simple inspection to occur with each of these peculiar objective noises, I placed a small glass manometer devised by Politzer,

Fig. 72.
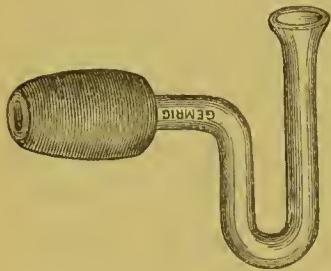
POLITZER'S MANOMETER.

with its capillary calibre, one millimetre in diameter, filled with colored water, into the meatus of the right ear, also filled with water, the two columns of water being hermetically joined by an India-rubber stopper on the manometer. The column of water thus brought into contact with the membrana tympani, showed a negative fluctuation of one-half millimetre at each snapping sound, thus demonstrating a retraction of the membrana tympani too small to be seen at that time by inspection, but later, apparent upon close and attentive inspection. The drum-head moved readily under the Siglé pneumatic speculum.

The examination of the fauces revealed an elevation and retraction of the velum palati, chiefly on the right side, with each snapping sound in the ear and each manometric depression. The negative fluctuation—i. e. depression in the manometric column—amounting to one-half millimetre, occurring at each objective sound in the ear, was entirely distinct from a very

slight positive oscillation in the same column at each cardiac impulse. The latter could not always be discerned.

Deglutition, respiration, and speech exercised a marked influence over the spasmodic condition already described. The patient stated that deglutition and rapid respiration increased the frequency of the snapping noise in the ear, but that when he held his breath, the spasms in the velum palati and the snapping noise in the ear, ceased entirely, to begin again with renewed respiratory acts. I found, indeed, that so long as the patient held his breath neither he nor I could hear any snapping, nor could I detect any spasmodic movement of the velum; but they all recurred as soon as the patient resumed his breathing. During ordinary respiration I counted twenty spasms in a minute, which appeared to be the average number; but with a voluntarily increased number of respirations, the number of snappings and spasms of the velum rose to thirty in a minute. ' During continued speech no snappings occurred.

These peculiar snappings were not in regular succession, nor synchronous with the respirations. Two or three snappings usually occurred in quick succession, were followed by a pause, then there were several more, thus completing twenty in a minute. These noises interfered so much with the hearing in the ear in which they occurred, that the patient, when specially desirous to increase his hearing, held his breath, which, as already stated, would control the spasms. It was found by testing with a watch, audible normally sixty inches, that the hearing was indeed influenced by the spasms and their temporary cessation, as the patient had stated ; for the watch, audible to him only on contact during the spasms, was heard two inches when the noises were arrested by holding his breath.

Tuning-forks held before the ear, appeared to the patient to rise in pitch at each spasm. The rise in the note was well imitated by the patient. This altered pitch was to be expected, because at each spasm the drum-head was retracted, and rendered, by this increased tension, more sensitive to high than to low notes, and hence the ear perceived the higher, to the exclusion of the lower partial tones of the tuning-forks.

The snapping sounds, but not the spasmodic elevations in the velum, could be arrested in two other ways. By throwing the patient's head back as far as he could get it, although the

spasms in the velum palati went on with the usual intervals, the objective noises in the ear were arrested.

I could also stop the noise by pressing my finger firmly against the velum, and pushing it upward towards the pharyngeal opening of the right Eustachian tube. Although a powerful twitching, with the usual intervals of repose of the muscular structures thus pressed upon, could be felt, all snapping noises ceased.

Pressure upon the left half of the velum palati and mediately upon the pharyngeal opening of the left Eustachian tube revealed no twitching in that region, nor did it influence in any way the spasms and noises on the opposite side of the pharynx and in the right ear.

As the patient expressed no desire for relief from this objective noise in the ear, seventy-two days went by, with a number of opportunities of observing all the phenomena just detailed. On the seventy-second day after I had first heard the snappings from the ear, the patient informed me that within a few days, a perforation had occurred in the drum-head of the ear from which the noises emanated, and that the latter had greatly decreased in loudness and frequency. Inspection then revealed, indeed, a perfectly well-defined dry perforation in the antero-superior quadrant of the membrana tympani, where previously the slight but spasmodic indrawing of the membrane had been observed ; but there was no explanation of the perforation so far as could then be discerned, nor could the patient give any solution of its occurrence. In a few days, the snappings, which had become very infrequent and nearly inaudible, *ceased entirely.* Although a little mucous discharge ensued in about a week after the perforation, probably from exposure of the mucous lining of the tympanic cavity to the winter atmosphere, it was easily checked, and the membrana tympani closed. Since then there has been *no return of the snapping noises, nor any spasmodic motion in the velum palati, Eustachian tube, middle ear, nor membrana tympani.* The young gentleman has remained under observation until his return to Japan in the autumn of 1876.

Causes.—The causes of the occurrence of involuntary objective noises in the ear, have been sought for in several ways, as in neuralgia of the superior maxillary branch of the fifth pair, with tic of the seventh, and of the branch which the inferior

maxillary sends to the tensor tympani by means of the otic
ganglion (Leudet), or in a reflex spasm, conveyed from the
sensory nerves of the diseased mucous membrane to the cor-
responding motor nerves, in cases connected with catarrh of the
pharynx (Küpper).

It is a notable fact that many of these occurrences are in con-
nection with catarrh of the pharynx, but that is not considered
sufficient by Küpper to account for the spasms. They may be
explained by a predisposition to spasmodic affections in the
individual. As an analogue to this peculiar affection of the ear,
Dr. Küpper cites spasms of the orbicularis palpebrarum in con-
nection with diseases of the conjunctiva. They might also be
explained as already suggested. Doubtless the retraction of the
membrana tympani in some instances of objective noise in the
ear, may have been due to a contraction of the tensor tympani
muscle, but in the single case which I have observed, I believe
the retraction of the drum-head was due to the formation of a
vacuum in the tympanum, produced by the sudden drawing
apart of the walls of the faucial mouth of the Eustachian tube.
This I consider all the more probable since the retraction ceased,
as did the spasm of the velum and the noise, as soon as the
membrana tympani ruptured.

Treatment.—The whole number of these cases is so small, and
the individual experience in regard to them is so limited, that
our knowledge respecting the therapeutics of this variety of
aural disease is of course very meagre. So far as we can glean
an opinion from what has been written concerning the treat-
ment of these cases of clonic spasms, the induced current has
effected the only apparent relief and cure (Schwartze, Politzer,
and Boeck). This was tried without any good effect in the case
narrated as occurring in my own experience. Since spontaneous
perforation of the membrana tympani was soon followed by
entire cessation of the clonic spasm in the velum, and elsewhere
in the ear, and of the peculiar noises in the ear, I would recom-
mend artificial perforation in any similar case, if relief from the
symptoms should be urgently required.

Extravasation of Blood into the tympanum in Bright's Disease of the Kidneys.—An extravasation of blood into the

tympanum in Bright's disease has been observed by Schwartze,[1] Buck, and others. It has likewise been observed[2] that deafness is a symptom of Bright's disease not directly traceable to uræmia, and that pain and suppuration may occur in the later stages of this malady.[3] In the latter instance Dr. Roosa has thought, that there was every probability that the tympanic disease had originated in an extravasation of blood into the drum-cavity.

It is not difficult to comprehend how, in the atheromatous and weakened condition of the vascular system in this form of renal disease, an extravasation may occur in the ear as it does in the eye and elsewhere. Hence such an occurrence in the ear might be an aid in diagnosing the existence of the above-named affection of the kidneys.

Otitis Media Hemorrhagica.—Under this name Dr. Roosa[4] has reported two cases of "acute aural catarrh which had an unusual course and termination," inasmuch as the disease ran a rapid course terminating in perforation of the membrana tympani without suppuration, but with hemorrhage through the ruptured membrane. This affection, according to Dr. Roosa, is to be considered entirely different from the process occurring in the atheromatous vessels of the tympanum in some cases of renal disease: on the contrary, it is to be considered an acute inflammation of the lining membrane of the middle ear, terminating in rupture of the vessels, hemorrhage into the tympanum, and rupture of the membrana tympani without suppuration. This disease has been also observed by Dr. Mathewson, of Brooklyn, and Dr. Hackley, of New York.

Tubercular Disease of the Ear.—Dr. Schütz[5] has made a study of tuberculosis of the inner and middle ear with special reference to the etiology of this process and the manner of its further dissemination throughout the body. His investiga-

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[1] Archiv f. Ohrenheilkunde, Bd. iv. p. 12.
[2] G. M. Smith, Transact. N. Y. Academy of Medicine, vol. iii.
[3] Roosa, op. cit., p. 257.
[4] Treatise, p. 254.
[5] Die Tuberculose des inneren und mittleren Ohrs beim Schweine nebst. etc. Virchow's Archiv, lxvi. p. 93. See review by Steudener, A. f. O., pp. 130-132, vol. ix.

tions show that the disease is usually ushered in by a catarrh of the pharynx, accompanied by a pulpy swelling and subsequent cheesy degeneration of the neighboring lymphatic glands (lymphatic catarrh), and finally passes into the tympanic cavity through the Eustachian tube. The disease then attacks the bony tissue of the pars tympanica, which soon passes into a state of proliferation, and in the inflamed and swollen tissue the first small gray tuberculous nodules make their appearance (tuberculous osteomyelitis of the pars tympanica). At the same time small miliary nodules arise in the inflamed mucous lining of the cavum tympani. The tuberculous new formations finally fill completely the drum-cavity, dislocating the auditory ossicles which become necrosed. The entire pars tympanica is changed into new growth, and the disease advances in a peculiar manner along the tracts of the nerves which touch the tympanic cavity.

At an early period the tuberculous growth penetrates into the Fallopian canal and attacks the facial nerve, which by this deposit of tuberculous nodules in its interstitial connective tissue, is entirely separated into its individual fasciculi. Finally the internal ear is attacked, the semicircular canals and the cochlea are filled with an exuberant tuberculous mass, which by the way of the aquæductus vestibuli et cochleæ passes into the cranial cavity. In the same manner the process advances in the connective tissue of the acoustic nerve and into the internal auditory canal, from which at last a tumor as large as a walnut may extend into the cavity of the cranium. It is worthy of remark that the dura mater is never invaded by the new growth; it is only pushed ahead of it towards the brain.

From the tympanic cavity the new growth, after it has embraced the membrana tympani, passes into the external auditory canal and extends as a nodulated polypoid excrescence over the sulcus tympanicus and outward beyond it.

At a later period, caseous as well as fibrous and calcareous transformation, takes place in the morbid growth. Secondarily, tuberculous eruptions may occur in any other of the organs of the body.

Desquamative Inflammation of the Middle Ear; Cholesteatoma of the Petrous Bone.—Dr. Wendt has given a new explanation of the greatly discussed question concerning

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the true nature of the so-called cholesteatoma of the petrous bone. He believes that in these cases there is present a special kind of inflammation which he terms desquamative. This disease is regarded as a collection of epithelium which is thrown off by the mucous membrane of the middle ear, in altered form and increased quantity, and which, finding no way of escape, is accumulated in the cavities of the middle ear, until it gradually fills them.

Eleven cases of this disease were observed in the living, one of which was examined *post mortem*. In every case the collections were composed of cells resembling scales of epidermis. The cells were arranged in lamellæ, through which were various, but never large quantities of oil and cholestearin. In six instances the point of origin of these masses was undoubtedly the tympanum. In the other cases, simply their presence but not their origin in the tympanum could be shown.

Dr. Wendt has based upon his clinical and anatomical studies the following conclusions:—

" 1. In some cases collections of a peculiar matter resembling greatly the cerumen, are found in the external auditory canal, and in the osseous middle ear.

" 2. These masses originate in a desquamative inflammation, characterized by a prolific growth and exfoliation of epidermis-scales entirely like the cells of the mucous membrane of the osseous middle ear, the epithelial lining of which, during or after a chronic inflammatory process, may, by exposure to external irritation, through the perforated membrana tympani, assume a cutaneous nature with the formation of a rete Malpighii, and external layers, which on account of the clogging up of the ear and the consequent shutting off of the air, may undergo partial fatty degeneration.

" 3. They produce hardness of hearing of a moderate degree when they are dry and loosely placed, and when no greater changes in the sound-conducting apparatus are present. When the opposite conditions prevail, the deafness is of a high degree, and pain will be produced if these masses swell, either under the influence of spontaneous suppuration in the middle ear, or of moisture from without.

" 4. They can produce important changes in the ear, the petrous bone, and even in the contents of the cranium, by means of the

pressure they exert in their vicinity when they soften and swell, and also by their growth; perhaps too their size may increase by absorption of the broken-down fluid elements of themselves or of neighboring pathological formations.

" 5. Their removal, though usually attended with pain and tediousness, is absolutely imperative.

" 6. It is not improbable that similar masses originating in a chronic inflammation of the walls of the external auditory canal, may pass into the tympanic cavity through perforations in the membrana tympani and produce there the same symptoms.

" 7. The collections of epidermis-cells, described in the literature as cholesteatoma of the petrous bone, are likewise to be regarded as products of a desquamative process in the middle ear, until it shall be proven by a comprehensive study of the masses, that they originate in some other way."

Prof. Von Troeltsch is of the opinion that cholesteatoma and the above described process in the petrous bone, are distinct and separate diseases.[1]

New-formed Membranes and Bands in the Middle Ear.
—Morbid membranes and bands occur very often in this cavity, and are very delicate in consistence and of a whitish or gray tint. In the membranes there are deficiencies which can be detected macroscopically; in the synechial bands these deficiencies are seen only under the microscope. All of the above-named new formations (membranes, bands, and cords) may be found in the same ear. Their situation is very varied, they may connect the various walls of the tympanum with each other and with the ossicula, they may be found in the mastoid cells, in connection with the membrana tympani, spread over the round window and the niche of the oval window, the rami of the incus, the stapes, and over the tympanic mouth of the Eustachian tube, and the tendon of the tensor tympani.

Calcareous and osseous deposits may occur in these growths; the functional derangements depend upon the consistence and situation of the latter. The diagnosis of these structures is

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[1] See fifth edition of his Treatise, pp. 422-427; and the review of Wendt's papers, Archiv f. Ohrenh., B. ix. p. 124.

possible during life if the membrane is thin enough, and Siglé's pneumatic speculum is used to aid in the examination. Respecting the treatment, Prof. Wendt lays greatest stress on prevention; the perfectly visible ones may, in some instances, be relieved by operations, which must consist in excision of a part, and not simply incision.[1]

Treatment.—Respecting the treatment, Dr. Trautmann very justly says : "After the pathological process has set in, constant use of the catheter, by stretching and positive atmospheric pressure, will do more in producing atrophy and complete destruction, perhaps entire cure, than an operation in which a piece of the morbid deposit must be cut out in order to prevent fresh adhesion. Such an excision becomes very unsatisfactory, since the remote point of attachment of the morbid ligament cannot be seen."

The Corpuscles of Politzer and Kessel ; Prof. Wendt's Examination.

—Prof. Wendt has subjected these structures to a careful examination, and concludes that too much importance has been attached to them by their discoverers. He has found these thickenings on the cords and bands in the tympanum and mastoid cells in thirty-three per cent. of all cases examined, both in the healthy and in the diseased ear. The form of these bodies is very varied, and by no means as typical as held by Politzer and Kessel. Both Wendt and Trautmann believe that the majority of these bodies are fœtal remnants, though a few of them may be of recent date and of pathological origin. Dr. Trautmann considers them entirely insignificant, unless, on account of their situation and rigidity, they should become mechanical hindrances to the function of the middle ear.[2]

Embolism in the Mucous Membrane of the Tympanic Cavity.

—In some instances of general embolism and pyæmia, it has been supposed that embolism may occur in the mucous lining of the tympanum.[3] In such a case observed by Wendt

[1] Prof. Wendt, Archiv f. Heilkunde, 1874, pp. 97–100 ; also review by Dr. Trautmann, in Archiv f. Ohrenh., B. ix. 279–281.

[2] See review of Wendt's paper by Dr. Trautmann, Archiv f. O., B. ix. p. 281.

[3] Wendt ; A. f. O., Bd. ix. p. 121. Abstract by Von Troeltsch.

there were found, besides naso-pharyngeal catarrh, great altera-
tions in the drum-cavity. The latter consisted in excessive
swelling, maceration and friability of the mucous membrane,
which appeared to be stained with the coloring matter of the
blood, and filled in its interstices with blood-corpuscles. The
stapedes were buried in the swollen membrane, which fact pro-
bably helps to explain the great and sudden deafness which
preceded death. The changes in this case were referred by
Dr. Wendt to embolism of the tympanic artery, but the embo-
lism could not be found.

Primary Cancer of the Middle Ear.—Cancerous disease
often passes from neighboring tissues to the middle ear, as, for
example, in cancer of the auricle,[1] cancer at the base of the
skull,[2] malignant disease of the parotid gland,[3] and of the
antrum of Highmore,[4] but cases in which it can be shown that
the primary seat of the cancer has been in the middle ear are
extremely rare.

Instances of primary cancer of the middle ear have been
recorded by Toynbee,[5] Billroth,[6] Wilde,[7] Travers,[8] Wishart,[9]
Böke,[10] Robertson,[11] and Schwartze,[12] as referred to by the latter.

History, Course, and Symptoms.—In most cases there is a his-
tory of previous chronic purulent discharge, from the ear which
finally becomes the seat of the primary cancerous disease. The
purulent affection may continue for a long time before the
symptoms of the malignant disease appear. These are usually
more or less sudden hemorrhages, with a more acrid and fetid
discharge from the ear, and at the same time the ear becomes
the seat of constant and increasing pain. The parts about the

[1] Gruber; Lehrbuch, p. 596.
[2] Türck; Zeitschr. der K. K. Gesellschaft der Aerzte zu Wien, 1855.
[3] Schwartze; Archiv f. Ohrenh., Bd. ix. p. 215.
[4] Schwartze; Ibid.   [5] Diseases of the Ear, chap. xvii.
[6] Archiv f. Klin. Chirurgie, x. 67.
[7] Quoted by Schwartze, loc. cit.   Osteo-Sarcoma.
[8] Froriep's Notizen, Bd. 25, No. 22, p. 352.
[9] Edinburgh Med. and Surg. Journal, xviii. p. 393.
[10] Wiener Med Halle, 1863, Nos. 45 and 46.
[11] Transact. American Otol. Soc., 1870.
[12] Archiv für Ohrenh., Bd. ix. p. 208, 1875.

ear may become swollen and infiltrated, at last breaking down into ulceration.

An abscess not uncommonly forms over the mastoid portion, and in a short time sequestra may escape from the sinus left by the circumscribed inflammation. The hemorrhages may now become less frequent, but a discharge more or less copious and of a sanious nature still continues from the ear.

The hearing is of course greatly impaired ; if the tuning-fork is not heard on the vertex, the disease may have invaded the labyrinth.

Facial paralysis may ensue, and the glands near the ear usually become infiltrated and may suppurate. As the tissues about the ear break down, forming ulcers with eroded edges, the hemorrhages from the ear increase in amount and frequency, the pain is terrific, and the fetor intolerable. In the case reported by Schwartze, the palate became paralyzed on the affected side. Finally the patient dies from exhaustion.

Etiology.—Toynbee thought that, so far as his experience and observation had gone, malignant disease of the ear most usually arose in the mucous lining of the tympanum.[1]

Schwartze[2] believes with Roosa[3] that malignant disease in an ear, previously affected with chronic and neglected otorrhœa, may have its origin in the latter process. Both of these authors are of the opinion that some of the cases of death supposed to be due to the removal of aural polypi, should have been referred to an extension of a malignant disease, rather than to the excision of a tumor. Gruber states that malignant growths in the middle ear are usually the result of extension thither from neighboring parts, as, epithelial cancer from the external ear, and fibrous and medullary carcinoma from the pharynx or from the dura mater.[4]

Treatment.—It has generally been supposed that treatment is futile in these cases, but Schwartze claims to have obtained beneficial results from perforation of the mastoid process, when the disease has seemed to be extending inward, or to be pent up in the tympanum and mastoid cavity.

[1] Op. cit., p 386.
[2] Op. cit., p. 218.
[3] Treatise, p. 394.
[4] Lehrbuch, p. 596.

Cancer of the Mastoid Process.—The mastoid process may become the seat of cancer, as shown by Rondot.[1] Its history and symptoms are similar to those given as characteristic of primary cancer of the middle ear, inasmuch as it seems to be a consequence of neglected chronic otorrhœa.

The earliest symptoms, besides the chronic aural discharge, are hemorrhages from the ear, soon followed by intense pain and swelling of the mastoid and the parts about the seat of the disease, great deafness, and tinnitus aurium. As the disease advances, facial paralysis may ensue, the mastoid portion becomes more swollen and painful, the extreme point of the process may be most tender, giddiness and vomiting are apt to be joined to the other symptoms, and the entire mastoid region is covered with suppurating and fungoid nodules.

Emphysematous Tumor over the Mastoid Portion.—Natural dehiscences in the mastoid portion of the temporal bone sometimes persist, and favor the escape of air from the middle ear and mastoid cavity to the skin lying over the latter, as has been observed in a case reported by Prof. Wernher,[2] of Giessen.

This curious affection may show itself suddenly after an ordinary act of sneezing, in the form of a tumor, the size of a pigeon's egg, over the mastoid. There is no pain attending its formation, and the patient may be entirely unconscious of its occurrence. So perfect may the connection be between the mastoid cavity and the emphysematous tumor, that gentle pressure will force the air from the latter into the middle ear and fauces; but renewed expiratory efforts will reproduce the tumor. Gradually such a formation over the mastoid may extend, until the entire corresponding half of the scalp is involved, and the latter is lifted at some points 1½ to 2″ above the skull, as was observed in the case referred to.

The middle ear and membrana tympani may be normal, but a large dehiscence, the remnant of the natural openings in the infantile bone, may be found running across the entire mastoid

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[1] Annales des Maladies de l'Oreille, p. 227, 1875.

[2] Deutsche Zeitschrift für Chirurgie, Band iii. ; also Archiv für Ohrenh., Band ix.

portion, as in the case reported by Wernher. Compression long kept up, having failed in the case reported, to produce a cure, a successful endeavor was made to set up adhesive inflammation between the edges of the dehiscence and the superjacent soft tissues. This was accomplished by means of subcutaneous injections of tincture of iodine at various points in the tumor.

Hairs in the Mastoid Cells.—Another curious condition of the mastoid cavity is the following, related by the late Mr. Toynbee. He showed[1] a specimen of hairs in the mastoid cells, and said that according to his experience the case was unique. The hairs were firmly imbedded in the mastoid cells, and surrounded by masses of epidermis. Dr. Tilbury Fox, who examined them, agreed that the hairs could not have been introduced from without, but were nourished in the cells.

CHAPTER V.

ACUTE PURULENT INFLAMMATION.

THE disease previously treated of, catarrhal inflammation of the middle ear, is characterized by its tendency to harden and stiffen the original tissues of the ear, and in some cases to develop hypertrophy of the same. But purulent inflammation of the middle ear, which it is now proposed to consider, is characterized, both in its acute and chronic form, by its tendency to break down and to destroy the tissues of the ear invaded.

These two distinctions cannot be too constantly kept in mind, when endeavoring to study diseases of the middle ear, for it will be found upon careful examination that every inflammation invading the mucous membrane of the middle ear, in the vast majority of instances, must be placed in one of these two general divisions. Already it has been shown that catarrhal inflammation of the middle ear is conservative of tissue, and limits itself strictly to the ear. But there is another large

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[1] From the report of the Pathological Society of London, in the Medical Times and Gazette, March 3, 1866, p. 238.

number of cases of inflammation of the mucous lining of the middle ear, which tend at the outset to the formation of pus. This form of inflammation of the middle ear, not only breaks down and destroys the tissues of the ear, but it is characterized by its tendency to invade other parts of the head, especially the cranial cavity. In this virulent form it not unfrequently produces pyæmia, cerebral abscess, and death.

SUBJECTIVE SYMPTOMS.

The subjective symptoms of acute purulent inflammation of the middle ear are usually very rapid and violent in their succession. They are chiefly itching and tickling, referred to the Eustachian region and the ear; a sense of fulness and pain deep in the ear, which is greatly increased by coughing, sneezing, talking, or eating; tenderness of the adjacent maxillary articulation (though the latter symptom is not as marked in this disease as it is in inflammation of the external auditory canal); vertigo; tinnitus aurium; and hardness of hearing.

To these distressing symptoms in the ear, is added pain in the side of the head corresponding with the affected ear, running forward to the eye, temple, and frontal sinus, and backward to the occiput.

The condition of the sufferer becomes at last most pitiable; every movement of the head and body causes intense agony, the eyes roll about in a frenzy of pain, no comfortable position can be obtained either in sitting or in lying down, and even the strongest man may be forced to shriek, so dreadful is the suffering from acute purulent otitis media. If the victim is an infant or young child, all these symptoms may be mistaken for another disease, very often for incipient brain-disease, and this erroneous opinion is all the more confirmed by the not uncommon convulsion, into which the child may be thrown by its frightful sufferings. Usually these symptoms are relieved by a spontaneous rupture of the drum-head and escape of purulent matter. But this result will be more fully discussed under the consideration of the objective symptoms of the disease.

It becomes indeed one of the prime duties of a physician to be on the lookout for the acute occurrence of this disease in children, for upon its timely recognition may depend the life of the

little patient.   Certainly much suffering would be avoided, perhaps many lives saved, if the ear were even once thought of as the possible cause of an apparently obscure disease, in those too young to tell where the seat of their pain is.

Not only in children, but in adults, this disease is one of the *most* important the physician meets.

The importance of treating it properly in its acute stage cannot be too fully appreciated.   Yet it is lamentable to state that it is usually entirely disregarded.

Itching in Throat and Ear.—The itching and tickling of this disease are felt running from the throat, along the Eustachian tube, and to the depths of the ear, or *vice versa*.   Whether this is due to a direct passage of the inflammation from the throat to the ear, or whether it is purely reflex, like ear-cough, is not yet shown.

Very often this sense of itching is the first symptom which calls the attention of the patient to his ear.   It may, however, be entirely overlooked, and the ear is disregarded, until sharp pain in it arrests the attention of the sufferer.

Pain.—In the pain of acute purulent inflammation of the ear, we have perhaps the earliest diagnostic symptom of this disease. It will be found that, as a rule, the severity and continuance of pain is much more marked than in the catarrhal form of inflammation of the middle ear.

As has been stated, the pain in that disease is never so intense as in acute purulent inflammation of the ear, and it very often remits during the daytime ; but the pain in the acute purulent disease often leaps at once to an unendurable severity, and, if left to itself, is eased only by the escape of puriform matter from the tympanic cavity.   While the pain of the former is often not severe enough to keep the patient from his daily avocation, the pain of the disease under consideration is usually so intense as to excite secondary symptoms of fever, and in some cases delirium.

Alteration in Hearing.—At the beginning of this disease the hearing may become abnormally sensitive, and ordinary sounds will cause increase of pain in the ear.   The patient's own voice may also occasion him pain.   As the inflammation advances and its results are more fully established, the hearing will grow

dull, and by the time secretion is fully established, the deafness may be great.

The subjective noises are usually very annoying, and in many cases very distressing. Concerning tinnitus aurium and all kinds of so-called subjective aural sounds, the reader is referred to page 356.

Vertigo, Fever, and Delirium.—Vertigo may be a symptom in this as in many other aural diseases. It seems most marked after secretion is established, and before the membrana tympani is ruptured. It is, therefore, apparently due to pressure communicated to the labyrinth.

Fever and delirium, excited by the intense acute inflammation, must be treated on general principles, with this exception, that cold applications to the head, near the affected ear, should be avoided. While cold may allay inflammation elsewhere, no good results can come from its application to an acutely inflamed middle ear. This is due to the specially bad effects of cold in any form, upon the ear.

OBJECTIVE SYMPTOMS.

Membrana Tympani.—If the drum-head is examined in the early stages of this disease, it will be found congested at its periphery, and markedly about the membrana flaccida and the malleus. Gradually this congestion spreads inward from the periphery and outward, *i. e.* backward and forward from the manubrium of the malleus, until the entire drum-head is decidedly pinkish, with especially deep shades in its upper half. When so much congestion has occurred, the usual contour of the membrane will be less marked, the handle of the hammer will be less distinct, and the lustre of the dermoid layer and the pyramid of light will disappear. Vesicles may form on the membrana tympani at this point of the disease, but they are not common. The normal features of the drum-head are thus made to vanish, but in the lighter cases they may not become more distorted than above described, while in the severer cases the congestion and swelling of the membrane become so great that, at the fundus of the canal, there is only an undefined and sodden red diaphragm in the place of the normal drum-head.

Spontaneous Rupture of the Membrana Tympani.—This event is to be regarded as a chief symptom of purulent inflammation of the middle ear. Whatever may have been the nature of the inflammatory action in the tympanum at the outset, it will be found that when the disease has advanced so far as to produce spontaneous rupture of the membrana tympani, the matter discharged through such a ruptured spot will be of a purulent nature. This is in keeping with the tendency of the disease to break down tissue. Mucus in large amount may accumulate behind the membrana tympani, and, after clogging the tympanum for a time, be absorbed. I do not know, however, that if pus forms in the tympanum it is ever absorbed, or, if let alone, escapes in any other way than by spontaneously rupturing the membrana tympani. Nor does nature long delay the rupturing of the membrana tympani after pus has formed in the tympanic cavity. But mucus may lie in the tympanum long after all acute symptoms have subsided, and is usually the cause of the continued deafness after a comparatively slight attack of catarrhal congestion and inflammation.

In acute purulent inflammation of the tympanum, the membrana tympani will be found to be bulging very soon after the onset of the acute symptoms. It is usually confined to the posterior half of the membrana tympani, because all the efforts of blowing the nose, sneezing, and the like, force the products of inflammation backward toward the hinder part of the tympanic cavity.

I have noted that the presence of pus in the tympanum invariably causes bulging of the membrana tympani, while an equal amount of mucus usually does not produce a similar alteration in the membrane. So often has this been the case, that a marked bulging of the membrana tympani at its posterior segment might be regarded as diagnostic of the presence of pus in the tympanum. This has seemed to me to be due to the fact that catarrhal collections of mucus occur, if not in an ear the membrana tympani of which is already somewhat thickened by previous catarrhs, certainly in tympana thickened by the conservative nature of the catarrhal disease. On the other hand, purulent inflammation of the middle ear is much more likely to be found in a previously healthy ear, and in one apparently

not provided with any power to resist the destructive tendencies of the latter variety of inflammation.

Whether some diatheses have an inherent tendency to mucous results rather than purulent ones, after inflammatory processes in the mucous tract, and why this is, as it really sometimes appears to be, remains yet to be shown.

COURSE.

The course of acute purulent inflammation may, therefore, be said to be tending to a greater or less destructive process in the mucous lining of the cavity of the tympanum, and to rupture of the membrana tympani. The latter event is usually the first destructive result of the disease, and is very likely to give relief to pain. In some of the more violent cases, pain may not only continue, but increase after the rupture of the membrane. In such cases, a well-grounded suspicion may be aroused that the disease has invaded parts deeper than the mucous lining of the drum-cavity, and then it is likely that either the mastoid cells, or the cranial cavity, or both, may have become affected.

Authentic accounts of death resulting directly from acute purulent inflammation of the ear are rare—though doubtless death has occurred from this disease in its early stages, but has been set down to other causes. Death from the chronic form is a common occurrence.

Possible Fatality of the Acute Form of Purulent Inflammation of the Middle Ear.—It is a great misfortune, but one to be attributed to the hitherto imperfect means of examining the ear, and the consequent ignorance concerning the processes which go on there, that so few positive and accurate facts can be found as to the number of deaths occurring from acute purulent inflammation in a previously healthy ear. Most writers mention its occurrence, but few give details of cases.

Toynbee[1] found that the dura mater partook in the tympanic inflammation of typhus fever, which fact would seem to indicate that the tympanic disease shared largely in the fatal result. Itard, quoted by Toynbee, gives an authentic account of death

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[1] Op. cit . p. 32?.

in a short time after the onset of acute tympanic disease, the latter being undoubtedly the cause of death. Wilde[1] says death occurs frequently from acute inflammation of the ear, among the lower classes in Ireland; but he gives no account of these cases, probably because he considered them so well known as to need no illustration.

Dr. Edward H. Clarke,[2] of Boston, has narrated a case occurring in his practice, of a boy, in whom the acute inflammation of the middle ear proved fatal in fourteen weeks after its onset, by producing an abscess in the brain. In this case the inflammation of the middle ear passed through the tegmen tympani and thence to the brain. "The moisture and redness of the petrous bone at that point served to mark the track of the disease."

This case was of three weeks' standing when Prof. Clarke first had the opportunity of treating it, and he very justly observes: "If it had been possible to arrest the disease when it first attacked the ear, and before the bone, or rather the periosteum, was invaded, the life of the patient would probably have been saved."[3]

I saw, not long since, in the Philadelphia Infirmary for Diseases of the Ear, a case of acute inflammation of the tympanic cavity, in a woman thirty years old, which proved fatal in less than a month, by an extension to the mastoid cells and brain. The patient rejected the treatment proposed to her, viz., trephining the outer wall of the mastoid portion, and did not return to the Infirmary; but I learned from her friends that she at last succumbed, with every symptom of most violent inflammation of the brain.

Though these two cases show the course acute inflammation of the drum-cavity may take, it much more usually pursues a more favorable course. But they show the importance of early and intelligent treatment.

Darolles[4] has given an account of acute otitis media purulenta of the right side, followed by facial paralysis on the same side on

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[1] Op. cit., p. 241.
[2] Archives of Scientific and Practical Medicine, Jan. 1873, No. 1.
[3] Loc. cit., p. 47.
[4] Bulletin de la Société Anatomique de Paris, 1 fasc. 1875. See review by Kuhn, Archiv f. Ohrenheilk., Band x. p. 253.

the tenth day; acute meningitis was caused in this case by irruption of the pus into the aqueduct of Fallopius. On the sixteenth day profuse sweating, involuntary discharges of urine and feces, paralysis of the *left* arm, dilated pupils, reacting sluggishly, thready pulse, temperature 40.6° C. are noted. Death occurred the same evening. The post-mortem examination revealed: Veins of the pia and dura mater greatly congested; copious purulent infiltration into the subarachnoid cellular tissue, confined chiefly to the base, and the convexity of the right hemisphere; on the left side only those portions of the brain overlying the sphenoid bone were affected. Small insulated purulent foci were found along the bloodvessels of the convexity of the brain. The pia mater adhered at several points to the gray substance.

The outer surface of the petrous bone presented no abnormal feature, but the tympanic cavity was filled with pus, in which the ossicles floated about free. A small perforation the size of a pin-head was found in the upper segment of the drum-head; the mastoid cells were also filled with pus.

The facial nerve was exposed as far as its second turn, at the Fallopian hiatus, and was covered throughout its course with thick pus. The other walls of the tympanum were normal.

Dr. Gähde[1] has related a case of death resulting from an acute purulent inflammation of the middle ear. The patient was a young private soldier, under Dr. Gähde's observation in Magdeburg, Germany. The acute symptoms occurred on the 27th August, but appeared to subside after a slight discharge had occurred from the affected ear, the right. By the 12th September, however, the discharge from the ear and the pain having in the mean time ceased, the patient complained once more of pain in the ear, and his mastoid portion was found to be very sensitive to pressure.

Notwithstanding rest in bed and free leeching behind the affected ear, cerebral symptoms set in, and on the second day after the appearance of the symptoms, the man died.

The post-mortem examination revealed that the pus had accumulated in the tympanic cavity in large amount, but instead of bursting through the membrana tympani a second time and thus saving the life of the patient, it had forced its way into

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[1] Archiv f. Ohrenheilk. N. F., vol. ii. p. 98.

the mastoid cavity, and through a defective spot in its posterior wall until the products of inflammation were brought in contact with the dura mater. This of course set up an irritation in the covering of the brain, and fatal meningitis soon followed.

Might not a free opening in the membrana tympani have saved this man's life? Surely, had a free exit for the pus been provided by art, since it was not by nature, the results of the tympanic inflammation would not have found their way so readily to the mastoid cells and from that point, through a defect in the bone, to the meninges.

I have observed, not infrequently, that a perforation in the membrana tympani will heal up after giving vent to some of the products of inflammation in the tympanum, but before the cavity is entirely drained. If the case is watched now for several days, it will be found that there is a return of pain, and the drum-head will be seen to be bulging again. Disease may have already thickened it so much that it will not give way as quickly as it did before, and therefore it becomes imperative to open it artificially, and allow whatever may have accumulated behind it, to escape.

It may be said that sometimes the membrana tympani heals up too soon. In some cases before the acute process had entirely disappeared, I have found it necessary to puncture the membrana tympani several times.

By this means the drum-cavity has been kept thoroughly drained, and, as the mucous membrane lining it returned to its normal state, no excess of secretion has remained either to irritate the lining of the tympanum or to become the nucleus of an inspissated mass. The avoidance of the latter is of great importance. For, inspissated matter may cause not only deafness, but a form of deafness often ascribed to other causes. Without doubt many cases of so-called chronic thickening of the drumhead are in reality chronic accumulations of inspissated mucus, the remnant of half-cured, because improperly treated, catarrh of the middle ear.

ETIOLOGY.

The most usual causes of acute purulent inflammation of the middle ear are the exanthemata, local cold in various forms, and

direct violence to the ear. The first two are well known as the most fruitful sources of this severe malady. Whooping-cough also very often produces acute purulent disease of the tympanum.

When acute purulent inflammation arises in these diseases it is always a serious complication, chiefly because it is either unrecognized or neglected for the supposed sake of more attention to the general disease. The latter, however, can receive every possible attention, while the ear disease gets its share too.

Even if the attention is not drawn to the ear by symptoms of aural disease, the knowledge that the latter is likely to occur in the already named maladies, should prompt an early and careful examination of the ears in *every* case of exanthematous disease. If the treatment of the ear were made an important part of the general treatment, the latter would certainly be more effectual in the exanthemata, for not only would the general disease run a more favorable course in its acute stages, because relieved of a most painful complication, but there would be less chronic purulent disease of the ear with its dreadful results following in the track of the above-named affections. Mr. Hinton,[1] of London, was of the opinion that the mortality from scarlatina might be diminished by bestowing care upon the ears when affected by that disease.

Cold Bathing ; its Effect on the Middle Ear.—The effect of cold bathing on the ear has received of late a good amount of the attention due it. The exposure of the ear to cold water, in diving, sea-bathing, and the like seems to be a very common cause of acute inflammation in the middle ear. While it cannot be denied that sea-bathing may be very beneficial to certain forms of ear-disease, the contact of cold water with the membrana tympani is always fraught with danger to the ear.

Therefore all forms of cold water bathing must be so conducted as to preclude this dangerous contact of cold water with the drum-membrane. This can be done only by keeping the head above water, or by stopping up the external ears, if the head is to go under the surface of the water. This may seem an extreme view, and it may be said that thousands bathe without incurring acute inflammation in the ear. Such may be the case, but while acute processes may be avoided, it is equally

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[1] Questions of Aural Surgery, p. 133.

certain that the frequent contact of cold water with the membrana tympani, lays the foundation of *chronic* deafness of a catarrhal variety. In the latter case the conservative force of nature thickens the drum-membrane in order to resist the frequent assaults of the cold water, which is allowed to enter the external auditory canal.

It is noteworthy that no mammal but man goes voluntarily under water, without being provided with a means of preventing the water from running into the ears.

I am informed by a physician of the south, and it is a fact well known to others, that hunting dogs *taught* to dive, become deaf.

Acute Inflammation of the Tympanic Cavity produced by Concussion.—Now and then an acute inflammation in the drum-cavity is set up by a fall, a blow upon the auricle, or an explosion near the ear. In such a case the traumatic force seems to be the powerful compression of the air in the tympanic cavity and external auditory canal, brought about by the sudden concussion.

These cases are entirely distinct from cases of deafness resulting from concussion of the nervous apparatus of the ear. In the latter we find deafness, unattended by any signs of acute inflammation of the middle ear, the only symptom.

When an acute inflammation in the middle ear is caused by a fall, an explanation may be sought for in the peculiar way in which the force of the fall is spent upon the air of the tympanic cavity. The concussion of the air in this cavity may be so powerful as to really wound the mucous membrane. As no direct violence is offered to the middle ear in these cases, the inflammation must be due to the effect of the violent oscillation of the air in the tympanic cavity.

I have seen but one case of acute inflammation of the middle ear resulting from a fall, and that was in Prof. Politzer's clinic, in Vienna, in 1872. Prof. Politzer stated at that time, that " he had seen a few cases of what he termed *traumatic* catarrh[1] of the middle ear, a disease entirely distinct from those forms of disease resulting from concussion of the cochlea."

Acute Purulent Inflammation of the Tympanic Cavity, from a Blow on the Auricle.—The only case I have observed of acute in-

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[1] Saissy alludes to a similar form of disease, Eng. Trans. by N. R. Smith, Baltimore, 1829, p. 109.

flammation in the tympanic cavity, following a blow on the
auricle, happened in a boy thirteen years old, who was struck
on the ear by a ball.

There was in this case, very little external otitis, the auditory
canal remained unswollen, though rather more tender than
usual, there was pain deep in the ear, with tinnitus and deaf-
ness, great redness and swelling of the membrana tympani, per-
foration of the same, and a discharge of blood, mucus and pus
from the tympanum. Mastication was painful to the affected
ear, and the boy lost appetite and strength. Inflation of the
tympanum was easily done by the method of Valsalva and by
that of Politzer, showing no obstruction in the Eustachian tube.
The ear was syringed regularly each day with warm water, and
mild astringents were instilled into it, tonics were given, and
in six weeks the boy began to recover his health and hearing,
both of which were finally restored. Concussion plainly caused
this case of tympanal inflammation. Was it done by a sudden
compression of the column of air in the auditory canal, as the
ball struck the auricle, and by a consequent forcing inward of
the membrana tympani, and a compression or shaking of the
delicate structures in the middle ear ?

Of course, every surgeon knows that a direct wound of the
drum-head and mediately of the tympanic mucous membrane
and contents, may produce an acute inflammation of the middle
ear, but that which is specially referred to here is a form of
acute inflammation of the tympanum, brought about by con-
cussion. The powerful compression of the column of air in the
auditory canal and tympanic cavity, produced by the concussion,
is the only means by which the membrana tympani and drum-
cavity may be said to be struck, and it is this force which
probably causes the inflammation.

Very interesting cases of this kind of acute inflammation of
the middle ear produced by concussion, are four reported by
Dr. J. Orne Green.[1] Two of these cases of acute tympanal dis-
ease were caused by an explosion[2] of a bag of gas, one by a blow
on the ear from a policeman's club, and a fourth by a fall thirty

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[1] Trans. Amer. Otol. Soc., 1872.

[2] One of the two cases caused by explosion was under the care of Dr. Shaw,
to whom Dr. Green acknowledges himself indebted for the notes of the case
(loc. cit.).

feet, upon the head. In all of these cases the drum-membrane was ruptured by the traumatic force, and in the first three, purulent, and in the last-named, simple catarrhal inflammation ensued. These cases, as Dr. Green observes in his paper, are examples of accidental injury to the sound-conducting apparatus of the ear, and should be carefully diagnosed from cases of partial or total loss of hearing, from accidental injury to the brain or nervous structures of the ear. Such cases become of the greatest importance in legal medicine on account of the accuracy of diagnosis demanded by their occurrence.

Not long since, an intelligent man presented himself for treatment of deafness and tinnitus resulting, as he said, from a blow on the ear, from a policeman's club, a few days before. He stoutly asserted the integrity of his ear before the blow, but after removal of dry blood from the auditory canal I found an unmistakably chronically diseased drum-head, and, on examining the fauces, a markedly granular pharynx. On the next day, after the drum-head had become dry from the water syringed into the ear, it was found to be lustreless and retracted, the handle of the malleus prominent and twisted on its long vertical diameter, and the lower segment of the drum-head contained calcareous spots. The Eustachian tube was pervious to the air of the catheter.

With all these features of chronically diseased throat and a more or less atrophied drum-head, an opinion as to the *cause of deafness* should be given guardedly. It is well known that a progressive hardness of hearing may advance very far, before the attention of the patient is drawn to it. In the case just mentioned, it appears probable, to one familiar with aural disease, that the blow from the policeman's club was not the sole cause of the deafness, yet, at the first recital of such a case, one naturally thinks immediately of an acute injury to the nervous structures of the ear.

DIAGNOSIS.

In the diagnosis of this disease there are several prominent subjective and objective symptoms for guidance. In the first instance the severity of the pain will be so much greater and persistent than that of acute catarrh, that it alone will aid in

forming a true diagnosis, and the general systemic disturbance which also accompanies it, will be an additional evidence as to the real nature of this disease. With all this intense pain in the ear, we may be surprised to find the auricle and meatus not sensitive to gentle traction. This latter feature of the disease should at once free our minds from the idea that the pain is caused by any form of external otitis.

In either the circumscribed or diffuse variety of external otitis, the slightest manipulation of the auricle and auditory canal is usually attended with pain. The objective symptoms too, in external otitis, enable us to form a diagnosis between it and acute inflammation in the middle ear. The differential diagnosis becomes more difficult when there is a diffuse external otitis consecutive to the tympanic inflammation, especially if the former should close the auditory canal. This mishap, however, is not so likely to occur in the *consecutive* as in the *idiopathic* form of external otitis. Another aid in diagnosis is the fact that diffuse external otitis, consecutive to an acute inflammation of the middle ear, is comparatively rare, and not very rapid in its onset. Before it appears, an opportunity is generally afforded to examine the membrana tympani and establish a diagnosis of the original tympanic disease. If doubt is still present, as to the condition of the drum-cavity, its state must be further determined by the use of the Eustachian catheter, inspection of the fauces and nares, and a careful noting of all the general symptoms.

Earache from Decayed Teeth.—The pain of acute inflammation of the tympanic cavity may be confounded with that caused by decayed teeth. Von Troeltsch has already noticed that it is often difficult to distinguish pain in the molar teeth from pain in the middle ear. Many cases of earache occur, not only in those with neglected carious teeth, but in the more fortunate whose teeth are filled with gold. In the latter, otalgia is often produced by inflammation and caries beneath the filling. I see constantly many cases in the former class, in the infirmary, and now and then cases of the latter variety present themselves in private. Although, in such cases, the objective aural symptoms would remove all doubt from the mind of one familiar with the appearances of a normal ear, still, the possible cause of pain in the ear, arising from diseased teeth, should be borne in mind

until the diagnosis of a different cause is fully established. Whenever we find earache without sufficient objective symptoms of its cause, it is never amiss to inquire after the teeth.

Ran[1] says that, in young children, dentition is always attended with irritation in, and sometimes discharge from, the skin lining the external auditory canal. The fact that an unchanging pain is usually the *only* symptom present in otalgia from carious teeth, will aid the diagnosis.

Appearances of the Membrana Tympani.—As is the pain, so is the general alteration of the membrana tympani more intense in acute purulent otitis media. The membrane will be found passing from a stage of congestion around its periphery and malleus, to successive ones of greater intensity, until all its contours are lost, and either a bulging or misshapen diaphragm is seen at the fundus of the auditory canal. But we cannot point out any specific symptom in the membrana tympani as peculiar to this disease; it is rather the general and severe implication of the whole membrane that would seem to distinctively mark its condition in this disease.

Whenever any matter collects behind the membrana tympani, in quantities large enough to force the latter to bulge, such protrusion is almost invariably in the posterior half of the membrane.

Whenever the membrane appears to be in hillocks, or puckered, there is most probably exceptional implication of its dermoid layer, in all likelihood due to a consecutive diffuse external otitis. The latter may not advance further outward than the immediate region of the membrana tympani; or it may, unfortunately, invade the entire external ear.

PROGNOSIS AND TREATMENT.

The prognosis in properly treated acute purulent inflammation of the middle ear, though usually favorable, must always be modified by the cause of the disease and the general condition and age of the patient. The cases arising in acute exanthemata are the least favorable, because usually neglected. Those occurring in an ear previously diseased, or in one occluded to an

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[1] Ohrenheilkunde, p. 158, Berlin, 1856.

extent likely to prevent the escape of the products of inflammation, must be considered as gravely complicated, not only as to the hearing, but as to the life of the sufferer. An ordinary uncomplicated case of acute inflammation of the middle ear, arising from cold or exposure to traumatic violence, is rarely fatal to life. This disease usually causes some permanent alteration in the hearing, though the amount is small in the best cases.

The treatment of acute tympanic inflammation must be emphatically antiphlogistic. The first endeavor must be to reduce the congestion and pain and *to prevent suppuration*. This is best accomplished by leeching, the depletory effects of which are most successfully gained by placing the leeches close to the ear. The points to which they should be made to attach themselves, are close in front of the tragus and along the limits of the auricle where it fades into the cheek.

If the pain and tenderness are marked in the region of the mastoid portion of the temporal bone, some of the leeches should be placed in the hollow close under the auricle, and over the mastoid. The so-called European or Swedish leeches will be found the best, because the largest and strongest. From three to six of such leeches will usually relieve the pain and check the advance of inflammation, if they are put on in time. From three to six ounces of blood should be drawn in the earliest stages of the disease.

If any of the products of inflammation have appeared, depletion by this means is most positively contraindicated: if blood is to be drawn it must be done at the outset of the inflammation. Of course, this is a mode of treatment more easily carried out in a city and upon adults; but even children will submit rather than suffer, and where leeches cannot be gotten, Hourteloup's artificial leech may do us a good service. Unfortunately, however, the parts about the ear, being bony and uneven, are not well adapted to the firm suction this instrument requires. Blood should be drawn as soon as possible, and if not in any of the ways mentioned, I should rather resort to venesection than to run the chance of severe inflammation in the middle ear, with all its possible train of evils.

I have never resorted to the latter means of depletion for an inflammation in the ear, but, although it is not a local bleeding,

such as is demanded in these cases, it is not to be despised as a last resort where blood should emphatically be drawn by some means. Remember, we are endeavoring to check the advance of an *acute* inflammation.

Next to leeching, local and constitutional anodynes in doses to give ease and sleep, will do the most good. The local use of Magendie's solution of morphia (16 gr. to f℥j) will be found the most effectual. This may be used even in children, as an instillation into the ear, in quantities of five to ten drops at a time, *well warmed.*

The bowels should be opened as soon as possible by a saline purgative, and a mild sudorific should be given to place the skin in free action. It is of importance that the latter should be kept in brisk action during the acute stage of the catarrh.

If in spite of all depletory efforts, the inflammation is surely and plainly advancing, the ear should then be subjected to warm irrigation. This will most certainly give great comfort to the patient and hasten the formation of pus, if it must come; but in some instances I have thought the warm water-douche seemed to bring about a resolution of the inflammation, and thus spare the ear the ravages of a purulent process. Irrigation may be accomplished by the nasal douche, the fountain syringe, a siphon made of a bowl of warm water and a piece of rubber tubing or by means of Clarke's aural douche.

Paracentesis of the Drum-head.—The drum-head should be frequently and carefully examined, and if the slightest bulging appears in it, or if the products of inflammation become visible through it, and it appears likely to be ruptured, it will be better for the surgeon to choose the place of opening than to leave it to nature. The best point for paracentesis of the drum-head has been found to be the postero-inferior quadrant, for from that point the tympanic cavity is most easily drained. Nature may rupture the drum-head at any point, but since perforations in the posterior parts of the membrana tympani heal more rapidly than those elsewhere in the membrane, and as perfect drainage of the drum-cavity is very important and most easily accomplished from below, it is best to select the point named, for incising the membrana tympani.

Some authorities advise waiting until the membrana bulges before incising it. Then in order to relieve tension and to choose

the best place for the opening, paracentesis at the postero-inferior quadrant is advised.

Incision of the membrana tympani is so easily carried out, and in no event injurious, that it is not necessary to *wait* for protrusion of the membrana tympani, before incising it. Even in the earliest stage of tympanic inflammation, before secretion has appeared, paracentesis of the drum-membrane is often of great benefit. It relieves congestion and tension and reveals the condition of the tympanic cavity.

All forms of continued poulticing should be most carefully and especially avoided in acute inflammation of the drum-cavity. In the first place they cannot be brought into very close proximity with the diseased spot, and secondly, in any event, they favor too great a maceration, and consequent formation of granulations in the ear. They are therefore especially evil in aural diseases, for the formation of granulations, brought about by a poultice to the ear, may leave the organ chronically diseased, or destroy its functions altogether. This is the experience of every aurist, and is amply testified to in every modern work on Otology.

A kind of compromise may be made with the old prejudice in favor of poultices over the ear, by allowing the patient to wear a fold of cotton-wadding over the auricle and side of head, or to hold a warm hop-pillow to the painful ear.

But simplicity of treatment added to a careful and thorough diagnosis, are the best means with which to combat acute disease in the ear, as well as elsewhere.

CHAPTER VI.

CHRONIC PURULENT INFLAMMATION.

WHEN alluding to acute inflammation of the middle ear, the greatest stress was laid on preventing suppuration. If in spite of all efforts, suppuration does occur, or if before the patient consults any one concerning his aural disease, suppuration shall have become established in the ear, then every endeavor must be made to check the discharge. There should be no fear to do this as promptly as possible, for so long as a chronic purulent

discharge comes from an ear, the patient is in danger. There need be no anxiety therefore about "drying up" the running from the ear; "of driving it in on the brain," etc. Unhesitatingly it can be said that unless the otorrhœa is cured, the disease will surely extend to the brain. If it does not reach the brain, it will be because the patient will die of pyæmia and metastatic abscesses, before the central organ in the skull is reached.

Look at it then as one may, chronic discharge from the ear demands earnest consideration, careful and prompt treatment, and thorough cure, if it can be attained. So grave in fact is this disease that some insurance companies in Great Britain are advised by their medical examiners to refuse to take a risk on the life of one thus diseased.[1]

The hearing is generally gone, beyond hope of recovery, before any treatment is sought for or given to the purulent disease in the ear. At last the offensiveness of the running usually leads the patient to seek medical aid. The surgeon too often, after finding the hearing gone, advises the patient to let the discharge alone, "that it will dry up," etc. This is a mistake as fatal as it is common. Just because the hearing is destroyed, and the disease will advance from the middle ear to the internal ear, the mastoid cells, and the brain, the patient should be made aware of his condition and urged to undergo prompt treatment. His doctor should teach him that a disease which has destroyed the hearing can destroy the life; that cerebral abscess is but the logical sequence of such a corroding disease in the tympanum.

Treatment therefore should be instituted, not with a view of regaining the hearing, though some may be regained, but with the hope of freeing the patient from an offensive, annoying, and dangerous disease.

ETIOLOGY.

Respecting the causes of chronic purulent otitis media it is almost enough to say that they are the same as those productive of acute otitis media, and that the latter is the forerunner of the chronic form. Briefly, they are exposure to cold, traumatic influences, diphtheria, and the exanthemata. The latter, especially measles and scarlatina, are notoriously assigned as causes of a

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[1] Dalby; Diseases and Injuries of the Ear, p. 176.

large number of the cases of chronic purulent discharge from the ear, which the surgeon is called upon to treat. Most common of all assigned causes, is scarlet fever. The question naturally arises, is this necessarily the case; is there something in the scarlatinous poison which tends to eliminate itself through the mucous membrane of the middle ears? Can it for a moment be supposed that, just as the kidney is likely to become congested and inflamed in scarlet fever, so is the mucous lining of the ear? Since the throat and naso-pharynx are very apt to be diseased in scarlatina, and since an aural disease is prompt to follow close upon a throat-disease, the acute process in the middle ears, in scarlet fever, may be accounted for. But is there a specific tendency in the aural disease of scarlet fever, to become chronic? Upon close examination of these cases, it will be found that, though the sufferer has passed through a disease which has made him weak and liable to affections of the mucous tract, neglect of the acute inflammation in the ear has done the real mischief. Were this not true, then prompt attention to the inflamed ear in scarlatina would not be fraught with the good result it always is.

Diphtheria as a Cause.—Diphtheria is very often followed by a virulent form of chronic purulent inflammation of the ear, in children. There seems to be a tendency in this disease for the purulent otitis to fall at once into a chronic form. Pain is not always present and the acute stage is not well marked, but granulations spring up in a few days, the bone becomes necrotic, and sequestra are thrown off from various parts of the temporal bone. In a child sixteen months old, without any previous symptoms of pain or acute inflammation in the ear, a large cold abscess formed behind the auricle, pus ran from the meatus, the abscess was opened by the family's medical adviser, and denuded bone was found extending along the posterior wall of the external auditory canal and over the outer wall of the mastoid portion. In another instance, a little girl four years old was attacked with diphtheria; without any severe symptoms of acute otitis media, the child complained of discomfort in her right ear; then suddenly facial paralysis set in and continued for many days. This disappeared after a copious and fetid discharge from the meatus of the affected ear. Rapidly, without pain, an abscess formed over the mastoid and was opened, dead

bone was found in the auditory canal and over the mastoid; the ear was blocked with large granulations, and the major portion of the mastoid was thrown off as a sequestrum, from the opening behind the auricle. The rapidity with which the chronic form of purulent otitis is established in these cases, is worthy of note.

It is, therefore, advisable in order to prevent destruction of the ear, to examine the organ in every case of diphtheria, especially if the patient's attention is called to the ear by the least discomfort, and, if necessary, to make a free vent in the membrana tympani. This would permit the escape of matter from the drum, and prevent a burrowing to deeper parts. Such a procedure forms at least the best and perhaps the only means of preventing the rapid, almost gangrenous destruction of the ear, so likely to follow diphtheria in children. But ignorance of this fact, or unwillingness and inability to carry out the necessary manipulation in the examination and operation on the membrana tympani, have led the majority of physicians to underestimate the importance of doing that which is necessary to save the hearing and prevent necrosis of the temporal bone. Consequently the patient is said to have recovered from the diptheritic disease, in cases in which he survives, but his hearing is lost, and he is spared only to undergo a tedious and exhausting suppuration in his ear, and finally to die from an extension of the aural inflammation to the brain, or to other organs of the body, or from general pyæmia.

In order to convince one's self of the fearful ravages of chronic purulent inflammation of the middle ear, it is only requisite to take a casual glance at the literature pertaining to otology in Europe and America. But, though many cases of these evil consequences are recorded, every one whose attention is specially drawn to the point, will state that numerous cases of death, from aural disease, are put down to other causes.

Age and sex have nothing to do with the causation of chronic purulent disease of the middle ear in children. The desire on the part of parents to have their girls free from the necessarily disgusting feature of an offensive aural discharge, leads them to bring their daughters sooner perhaps than their sons, for treatment. Girls are more closely observed than boys, which also accounts for the fact that among young patients the girls are in the majority. Boys, with a chronic aural discharge, are more

likely to escape notice from the simple fact that they are absent from home more than the girls are. When, however, the boys begin to lag in their school tasks, on account of hardness of hearing, the aurist is consulted. Such circumstances may have more or less influence in causing an apparent preponderance in the number of young female patients, over that of the young males, but one sex is just as liable as another to chronic purulent inflammation of the middle ear, in childhood. Of adult patients afflicted with chronic purulent otitis media, the men seem to be in the majority. This is accounted for in part by the above-mentioned want of care bestowed on them in boyhood, and subsequently by their more exposed life. Among the patients met with in infirmary practice, females, whose lives are exposed, as servant girls, are just as liable as men to contract chronic purulent disease of the middle ear.

<center>SYMPTOMS.</center>

The chief symptoms of chronic uncomplicated purulent otitis media, are hardness of hearing, deafness, and an offensive purulent discharge from the ear.

The defect in hearing may vary from but slight hardness of hearing to absolute deafness. The vibrating tuning-fork on the vertex may be heard quite well in the affected ear if the labyrinth has not. been invaded ·by the inflammation. If the latter has advanced inward towards the labyrinth, then the auditory nerve will have been more or less affected, and the failure to hear the tuning-fork, by bone-conduction, can be easily accounted for, and must, therefore, as a rule, be regarded as an unfavorable symptom respecting the extent of the disease, and also regarding the prognosis. But it should spur on the physician to renewed efforts to quell an inflammation which has reached already so far, before it go further. While the deafness may be thus demonstrated to be absolute and irremediable, this fact is not sufficient to induce the physician to dissuade his patient from treatment, but rather to encourage him to go on, that matters get no worse.

The Discharge.—The discharge is usually much more copious in children than in adults. In the latter, the discharge is more likely to be copious the less chronic the disease, a feature, due

in all probability, to the more active condition of the inflamed mucous membrane. As the disease advances, the mucous membrane is either destroyed, or so greatly altered in structure as to cease to throw off much secretion, and the discharge in such cases becomes thinner, more offensive, irritating, and suggestive of necrosed bone. In children the discharge is copious because of the activity of the mucous membrane of the naso-pharynx, Eustachian tube, and middle ear. Hence, in these young patients the purulent discharge is mixed with ropes of mucus, quite transparent, from the Eustachian tube and the tympanum. The color of the discharge varies from a light-yellow to a dark-yellow or green, but there is no rule about this. I have observed that the more copious discharges of children are lighter in color than the scanty, which are usually darker. The slighter discharges of adults, afflicted with chronic purulent disease of the middle ear, are dark and more likely to form crusts or scabs in the meatus. In some rare instances the color of an otorrhœa may be bluish, as mentioned by Dr. Zaufal.[1] Such a discharge was found to contain the bacterium termo ; and the blue coloring matter gave a reaction characteristic of litmus.

In most cases there seems to be something almost specific in the odor of chronic suppuration from the ear. While this is hardly to be considered as necessarily so, it is so, mainly on account of the want of cleanliness. There will be very little odor in an ear thus affected. if it is kept clean and there is no necrosed bone retained. But if the latter provisions are not met, then of course all the peculiarly disagreeable and butyric odors of putrid pus and decaying bone will be emitted.

Appearances of the External Auditory Canal.—Inspection of the ear by means of the ear-mirror and the funnel will reveal maceration of the skin of the auditory canal, more or less destruction of the drum-head, and inflammation of the mucous membrane of the tympanic cavity. This is the view in an ordinary uncomplicated case; if there are complications arising from the purulent disease or from any other source, in the external or middle ear, they will now become apparent. But all such features of chronic purulent inflammation of the ear, will be considered under the consequences of the unchecked

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[1] Archiv f. Ohrenh., Bd. vi. p. 206.

disease. In order to obtain a good view of the external and middle ear, the auditory canal must be syringed out, and usually it will be found necessary to wipe off the drum-head with a little tuft of cotton-wool on the cotton-holder. This is demanded if the pus is tenacious or hardened on the membrane. Syringing without the latter manipulation has often led to error, since the red and inflamed parts beneath the film of tenacious muco-pus have not been seen.

Inspection of the external auditory canal in the simplest form of chronic purulent inflammation of the middle ear, reveals maceration of the cutaneous lining of the passage, and sometimes one or more exostoses. The latter are the more likely to be found the more chronic the case. They rarely exceed two in number. If the chronic discharge is not copious, the maceration of the skin in the canal is not great, and instead of that, there are found scales and crusts of hardened pus, mucus, and epidermis in the inner part of the auditory canal and on the outer surface of the upper part of the drum-head. In cases of copious discharge, the delicate lining skin of the inner part of the bony auditory canal, becomes more like mucous membrane than skin. This has led to the erroneous idea that the inner part of the auditory canal is normally lined with mucous membrane. It never is, but only assumes somewhat the appearance and nature of *diseased* mucous membrane, when subjected to constant irritation. This condition of the lining of the external auditory canal, is apt to be most marked in those individuals who have resorted to the injurious sponge-swab instead of the bland syringe, for cleansing their ears.

Appearances of the Drum-head and the Tympanic Cavity.—Chronic purulent discharge from the tympanum presupposes a perforation in the membrana tympani. Such a perforation may be at any point in the membrane, least frequently, however, in the flaccid part or the membrane of Shrapnell. A perforation in the membrana tympani may vary from the size of a pin's point to that which embraces the entire drum-head. Usually, even in the worst cases, a rim about the annulus is left, from which, if the purulent process is stayed, a new membrane may grow to a greater or less extent.

Multiple perforations are rare, sometimes two may be found close together in the under part of the membrane, separated by

a thin band, and, in very rare instances, three perforations may be found in the same membrana tympani. The handle of the hammer may remain intact, notwithstanding large destruction in the drum-head. In other instances, the manubrium may be more or less eroded as the perforation extends. If the membrane is destroyed, or if the perforation in it is in the upper and hinder part, the lower portion of the long process of the incus, the incudo-stapedial joint, and the rami of the stapes, as well as the niche of the round window, may come into sight after the ear has been well cleansed of pus and then dried out with cotton on the holder.

Nevertheless, a large perforation may exist in the upper and hinder part of the membrana tympani, and the aforesaid ossicles may be intact, yet invisible, for they are apparently a little higher in the tympanum in some individuals than in others. The mere fact that they cannot be detected in cases generally favorable to their exposure, does not prove that they are destroyed. In some cases, the mucous membrane around about them is too swollen to permit of their ready recognition. When a large perforation is about on the same plane with them, their lower ends may become visible by inclining the patient's head as far as possible towards the opposite shoulder, and looking up and behind the curtain-like rim of the membrana tympani, between them and the observer. In order to obtain a good view of the relations of these bones to each other, and of the separate rami of the stapes when they are to be seen, the patient's head will always have to be moved about gently from one position to another, till the desired view is obtained. The eye of the observer must always be directed towards the roof of the tympanum rather than towards the plane of the membrana tympani or inner wall of the tympanic cavity.

The appearance of the membrana tympani or its remnant, will vary from one of great opacity and grayness, with red and cicatrized edges of the perforation, to that of uniform redness and thickness. The manubrium of the malleus may be buried in the thick and swollen membrane, or, if the latter is gray and thickened, the position of the manubrium is marked often by only a tracery of congested vessels. In other cases, the handle of the hammer is seen as a ridge in the membrane of the same color, be that either red or gray; or, the handle of the malleus

may project alone in the plane of the former membrana tympani. In such cases, the so-called folds of the membrane may still remain, extending from the short process of the malleus, one backward, the other forward towards the periphery. It is usually the posterior one which interferes with a good view of the deeper-lying ossicles.

TREATMENT.

Two fundamental rules of treatment must be observed in every form of chronic purulent inflammation in the middle ear, cleanliness and perseverance. In some cases it seems highly probable that careful and thorough syringing of the running ear, several times a day, persevered in, would have cured the disease without the aid of astringents. It would certainly be far better to rely on the use of tepid water and the syringe, with a good hope of success, than to do absolutely nothing for the inflamed and offensive ear, since, in the latter course, the condition of the ear and of the patient will almost surely go from bad to worse. Especially at the beginning of the treatment should the ear be made clean, in order that its real condition should be seen, and then it should be kept clean in order that the remedies applied to the mucous membrane may have an effect. So important is this cleansing that it would be well to leave it to the surgeon were it practicable, but it is not. The surgeon, however, should cleanse the ear at least several times a week, at the outset of the treatment; in the mean time the patient or some member of his family should be instructed how the ear should and can be syringed. When this part of the treatment is learned by the patient or his friends, it can be left to them for the most part; however, the surgeon must frequently assure himself that the ear is properly syringed at home, for on that depends success.

I have never found it necessary or desirable to employ any of the heroic methods of forcing water either through the meatus, the middle ear, and Eustachian tube, or *vice versa*. Saissy, Millingen, and Hinton have advocated this procedure for cleaning the middle ear of inspissated contents arising in chronic purulent inflammation. If, in syringing the ear, some water escapes into the Eustachian tube and throat, it is of no moment. It may, indeed, be a sign of more thorough cleansing of the

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middle ear; but it is not desirable to force water to take this course, for, at the same time, some of it might be injected into the mastoid cells and there set up acute inflammation. In any event, forcible syringing of the ear is very liable to make the patient dizzy. Moderate syringing will not thus affect the patient: it is usually borne perfectly: only in one case of chronic purulent otitis media which came under my notice, no form or manner of syringing nor the aural douche could be tolerated, on account of vertigo, which was easily brought on. Cleansing the ear, in this instance, was effected by using a camel's hair pencil, moistened with warm water and a solution of permanganate of potassa. The patient was an intelligent adult, and could thus cleanse her ear moderately well. But, as a rule, such manipulation for cleansing purposes is to be forbidden, and total reliance on the syringe to be enforced. Sometimes, however, the most complete syringing will not remove all that should be washed out from the ear, especially the more tenacious variety of muco-purulent matter which collects like a film over the membrana tympani and the mucous membrane of the middle ear. In such cases, Castile soap may be added to the water, in sufficient amount to make the latter a little opalescent; or, before each regular syringing, a solution of bicarbonate of soda (10–20 gr. to f$\mathrecal{3}$j) may be instilled into the ear and allowed to soak there three to five minutes. Then, the matter thus softened may be more easily washed out. Still, in these cases, the surgeon must use his judgment as to whether the inspissated matter is to be removed or not. If the discharge is still active, then such masses should be removed, but if the running shows signs of stopping, it has seemed better in some cases not to wash these adherent films or crusts away. They do not invariably form; most discharges tending not to harden, but to come away if the ear is properly cleansed.

Not uncommonly, however, perforations in the drum-head close, first, by the formation of a kind of scab over the opening, then by true cicatricial tissue. The former finally falls off, leaving the latter as a permanent closure. But what I specially wish to call attention to is, *first*, the importance of favoring the formation of this scab-like closure in the perforated membrane of an ear affected with a chronic discharge from the tympanic cavity, and, *secondly*, the importance of letting such formations

alone when they have once closed the perforation in the membrana tympani. Such formations must be regarded as an effort of Nature to protect the lining mucous membrane of the tympanum. The normal drum-head must be regarded, to a very great extent, as a barrier between a mucous surface and the direct effects of cold air.

I have often observed that as a discharge from the tympanum ceases, the matter now being poured out in small quantities from the hole in the membrana tympani begins to stick to the edges of the vent Nature provided it, until, at last, a small scab or plug fills the perforation and the discharge has stopped. The application of remedies, now, must be timed so as not to prevent this forming of a natural plug for the hole in the drum-head.

When a discharge begins to diminish, it is decidedly better to taper off the amount of remedial applications to the ear; for they will not only prevent the healing or scabbing over of the perforation, but they will enter the tympanum, where they have ceased to be needed, and act as irritants. Doubtless, many discharges are kept up by continuing to syringe the ear and to put in drops. But no positive law on this point can be laid down. Each case must be studied pretty much for itself.

It will, however, never be amiss to pause in the instillations in order to find out whether there is really any further need for them, and to discover that which is still more important, viz., whether they are so far irritants as to keep up the slight discharge which still lingers.

Cessation of treatment is not unfrequently followed by the formation of the above-named covering over the perforation, and the healing of the ear. That this covering of yellow inspissated muco-purulent matter over the hole in the drum-head is of greatest value, is seen in those cases in which it has been unfortunately removed.

In several instances where such a covering had formed, before the cases came under my notice, and before I was aware of the real meaning and value of this natural patch to the wounded drum-head, in my zeal to remove what in one sense was a foreign body, from the membrana tympani, I softened the scab and removed it. In two instances a clean-cut perforation became visible, and through it the healthy mucous lining of the tympanic cavity could be seen. But in a few days the mucous

lining of the drum became congested, because the air had too free access to it, and an otorrhœa, which had subsided, returned.

Not only do I now leave such formations alone when found on the otherwise normal drum-head, but I have also learned that where the membrana tympani is largely destroyed, and the remnants of it and the visible parts of the cavity of the drum are smeared with a dense creamy matter, which cannot be called fluid, and therefore creates no discharge from the meatus, it is wise to leave such natural coverings alone, for beneath them are mucous tissues in the process of healing, and it is meddlesome to disturb them.

After a longer or shorter period these purulent coverings will dry, as the parts beneath heal and can dispense with them, and then they will peel off and escape as tough or hard shells. But unless there is an active discharge, running down the canal and out of the meatus, it is necessary to use great caution in removing what may be called aids to the natural repair going on in the tympanum and membrana tympani.

Too much can never be done to check a running from the ear; what has been said above is only intended to call attention to the importance of aiding nature in her process of repair, after an active discharge from the ear has ceased.

After careful observation of a number of cases of disease of the ear, it will not be difficult to discriminate between that which should be removed and that which should be let alone.

The Chief Remedies to Check the Chronic Discharge.—Cleanliness and perseverance have already been named as necessary rules in the general treatment of a case of chronic purulent otitis media. To these might be added three names to guide in forming a pharmacopœia, viz.: zinc, silver, and alum. Very few—perhaps none—of the numerous and ordinary uncomplicated cases of otorrhœa will defy the proper use of the syringe and the drugs named. The latter should be employed in the order in which they are mentioned, the first two in solution with water for instillation; the last in powder for insufflation. Doubtless many other drugs are useful as local applications to the chronically diseased ear, but they are emphatically in the secondary list.

Solutions of zinc, preferably of the sulphate, though the acetate is also very good, should be used in the strength of

from one to five grains to the fluidounce of water. Only in the rarest instances will any advantage be derived from increasing their strength beyond this point. If they are thus concentrated the discharges are curdled, the ear is blocked up and the fresh secretion retained.

Solutions of nitrate of silver are useless in checking a chronic discharge from the ear, unless used in considerable strength. The most efficient are those ranging from 30 to 100 grains to the fluidounce; and not uncommonly saturated solutions (480 gr. to f℥j) are instilled not only without injury, but with positive good, as shown by Dr. Pomeroy.[1] The solid stick should *never* be used.

Prof. Schwartze[2] was the first to draw the attention of the profession to the use of strong solutions of nitrate of silver; he considered those of 15 grains the weakest, and of 40 grains the strongest; latterly he has used much stronger solutions. It is not necessary to wash out the ear with salt and water after the application of the solution of silver. I think that caution demands careful consideration before very strong solutions of silver are instilled into the middle ear in chronic purulent otitis media, simply for fear of implicating the facial nerve. Though I have never met with such an accident, nor do I know of a reliable account of facial paralysis produced by the instillation of nitrate of silver into the tympanum, caution would forbid its use if there is any reason to suspect disease of the bone, for, if the latter exist, the Fallopian canal might be so far deficient as to permit some of the caustic to penetrate to the nerve. So long as there is reason to believe the chronic purulent inflammation has not advanced beyond the mucous tissues, there can be no harm in using solutions of nitrate of silver in the middle ear.

Prof. Schwartze's advice is adverse to instillations of nitrate of silver in solution unless there is positive evidence of the absence of granulations on the exposed mucous membrane or upon the remnants of the membrana tympani, and unless there is entire absence of disease of the bone. Prof. Roosa,[3] however, believes that nitrate of silver in strong solutions may be used

[1] N. Y. Med. Journal, Dec. 1872.   [2] Archiv f. Ohrenh., Bd. iv. p. 1.
[3] Op. cit., p. 376.

with safety and profit even where there are granulations and polypi. It has seemed to me that Dr. Pardee's[1] advice is timely, to regulate the choice of an astringent by the character of the secretion. Hence, if the discharge is predominantly of a mucous character, he advises nitrate of silver; if chiefly purulent, weak solutions of zinc, acetate of lead, and alum are to be used. Grossman,[2] as quoted by Schwartze,[3] advises the use of sulphate of zinc with catarrhal secretions, acetate of lead if the discharge is blennorrhœic and the perforation of the membrana tympani small, and crude alum in powder if the discharge is both blennorrhœic and copious and the perforations in the drum-head very large.

Mode of Instilling Solutions of Nitrate of Silver.—The solution need not be warmed, as shown by Politzer, though Schwartze pursues an opposite plan. After the ear has been cleansed and dried, let an ordinary medicine-dropper be filled with the solution of silver, and then, with the head of the patient slightly inclined forward and toward the opposite shoulder, drop the caustic fluid into the meatus. If the Eustachian tube is pervious, Valsalva's or Politzer's inflation may be performed while the solution is in the meatus. Bubbles of air will rise through the fluid in the ear, and, upon ceasing the inflation, the solution will find its way still more readily into the tympanum and Eustachian tube. Such a distribution of the fluid is desirable, since an application is thus made to the Eustachian tube and naso-pharynx, both of which are more than likely to be as much diseased as the tympanum in chronic purulent otitis media.

Prof. Schwartze has known an instillation of nitrate of silver to pass from the middle ear to the Eustachian tube and from the latter across the naso-pharynx to the tube of the opposite ear, causing acute inflammation of the latter;[4] an accident which he further warns against lately,[5] since he believes it very likely to occur if the head is laid in a horizontal position during the instillation. Although he has assured himself of this possibility by experiments on the cadaver, his experience, so far as I am aware, is solitary.

[1] Trans. Amer. Otol. Soc., 1871.   [2] Ungar. Med. Presse, 1870.
[3] Arehiv f. Ohrenh., Bd. vi. p. 32, 1873.
[4] Arehiv f. Ohrenh., Bd. iv. p. 233.   [5] Arehiv f. Ohrenh., Bd. xi. p. 122.

The application of solutions of nitrate of silver, should never be entrusted to the patient or his attendants, for, if it be, there is every likelihood of staining his ear and cheek, and ruining his clothing. To properly apply a solution of nitrate of silver is somewhat laborious, and hence not likely to be carried out in the vast majority of cases, unless by a skilful hand. From motives of cleanliness it is well to put salt into the water with which the ear is washed after solutions of silver are used, since they are thus neutralized, and little or no staining of the ear occurs. Beyond this object it is not necessary to neutralize the silver. But it is very obvious, that in a treatment which is more than likely to be tedious, every effort should be made to free the patient from the additional annoyance of black stains on his ear and his cheek, besides ruining his clothes and toweling. I have known patients to be justly indignant at having been advised to use an expensive solution, the entire nature of which they were unacquainted with until they discovered that, besides disfiguring their faces, they had ruined costly garments. Mothers who thus have been allowed to spoil their children's dresses, are not likely to be enthusiastic for a continuation of the use of silver, even when properly applied. Yet tucking a towel around the patient's neck and ear, be it child or adult, careful instillation of the silver solution, its momentary repose in the ear and its washing out with salt and water, will prevent any annoyance. In the ear, as in every other part of the body, it is usually more important how a drug is used than what it is. The diseased mucous membrane of the middle ear is not very sensitive, so that the patient can be assured the drops of nitrate of silver will not pain him. This assurance will be not only comforting but frequently demanded. The association of the names nitrate of silver and caustic will then cease to be as alarming as it often is, until the patient is reassured respecting his comfort. It must be stated, however, that if the skin of the external auditory is abraded in any way, nitrate of silver dropped into the ear will be for a moment acutely painful. But in such cases, the healing of these abraded cutaneous parts is brought about by the use of the silver, and there is no further pain. In the latter way, may be explained the assertion on the part of some observers that nitrate of silver dropped into the middle ear causes pain, when in reality the

pain is due to cauterization of an abraded spot in the delicate and highly sensitive skin in the inner part of the auditory canal. I have yet to see pain caused by contact of a solution of silver with the mucous membrane of a middle ear in a state of chronic purulent inflammation.

Alum may be used in solution or in powder; although some have regarded a solution of alum as most potent to check chronic otorrhœa, the powder is now almost universally employed for this purpose. After the ear is cleansed and dried, the powdered alum may be blown in by means of a simple instrument. I have used for this purpose a home-made instrument, consisting of a small glass mouth-piece—a piece of glass tube or a small olive-shaped nose-piece from the nasal douche will answer—and a flexible rubber tube 35 cm. long and 8–9 mm. in diameter, into one end of which a piece of quill 3 cm. long may be inserted. The latter at its free end can be cut diagonally to its long axis, thus making a scoop for the powder. With the canal and middle ear, or as much of it as is exposed to view, well lighted by means of the forehead-mirror, powdered alum may be blown into the ear with the above-described tube. The utility of the latter is greatly increased by the greatest amount of flexibility of the rubber tubing employed.

In many cases it will be best to allow the alum to remain several days at a time in the ear, as recommended by Politzer. If the discharge is still copious, it will run out, though the powdered alum is left in the ear; but if the discharge is slight, it will not accumulate fast enough to prevent the alum from remaining some time in the ear, and thus acting for a continued period on the diseased tissues. An ear undergoing this form of alum-powdering should be examined frequently by the surgeon, and if there appears to be a ball of alum and muco-purulent matter forming, it should be washed out. Usually, however, the best effects of alum are obtained by allowing it to remain indefinitely in contact with the diseased mucous membrane of the middle ear. Solutions of alum are apparently not as potent as the powder; and it is held by Von Troeltsch, and corroborated by others, that they cause furuncles in the cartilaginous part of the external auditory canal.

Other Powdered Substances for Insufflation into the Ear.—Dr. Hinton has found powdered talc of great use in drying up a

slight but persistent discharge; Dr. Chisholm[1] recommends a powder of two parts of magnesia and one of salicylic acid in chronic purulent otitis media. This is certainly a most impalpable and beautiful form of applying salicylic acid. Dr. F. H. Rankin,[2] of New York City, has recently recommended the use of powdered iodoform in chronic purulent discharges from the ear. After the ear is cleansed and dried, the iodoform is to be blown into the ear. I have used this, as well as equal parts of it and crude alum, in a number of cases, and I have thought I observed benefit from the application. The cases in which it has seemed of most value have been so-called scrofulous children. The peculiar odor, affecting some individuals really painfully, renders it objectionable as a means of treatment in private practice. It has never, so far as my experience goes, proven in the least degree irritating. Schwartze[3] recommends, as powders useful in checking slight chronic discharges from the ear, calomel (Rust), tannin, nitrate of bismuth, and magnesia usta (Hinton).

In the use of all kinds of powders for insufflation the greatest watchfulness must be observed, in order to prevent concretions of the matters thus blown in.

Other Astringents used in Chronic Purulent Otitis Media.—Sulphate of copper, acetate of lead, aluminate of copper, nitrate of lead (Von Troeltsch), and tannin are among the astringents which may prove of great benefit in some forms of chronic purulent inflammation of the middle ear. It will be observed in the vast majority of cases, the mineral are preferred to the vegetable astringents in the treatment of diseases of the ear. Tannin is rarely used, as it is regarded almost inert in checking a chronic purulent discharge from the ear.

Sulphate of copper is especially beneficial when the bone is diseased. It should be used in weak solutions (1–3 grs. to f℥j), as it is much more powerful than sulphate of zinc—*i. e.*, it will cause burning in the ear much more readily than the latter, if it is used in solutions of greater strength than just named. It was first recommended in aural diseases by Rau, and since,

[1] Philadelphia Medical and Surgical Reporter, vol. 33, p. 103.
[2] New York Medical Journal, May, 1875.
[3] Archiv f. Ohrenheilkunde, Bd. xi. p. 123.

greatly lauded both by Lucæ and Schwartze. I have never found that the slight staining of the ear, which it sometimes produces, has materially interfered with the proper examination of the diseased parts. It is a valuable astringent, but irritating unless used in weak solutions.

Preparations of lead, though admirable astringents, are open to the same objections in treating diseases of the middle ear, as in diseases of the eye. The insoluble precipitates with albumen which they form have caused their almost total banishment from the treatment of chronic purulent otitis media. *Lead-water* has been used by Wilde, Schwartze, and Politzer, with asserted success, in checking suppuration from the ear.[1] But they are very cautious in its use, for fear of the aforesaid tendency of it to form, like other preparations of lead, insoluble precipitates.

Nitrate of lead has been recommended by Von Troeltsch[2] as of some value in chronic purulent discharges from the middle ear, after other mild astringents have seemed to fail. I have used this preparation of lead in solutions of ten grains to f℥j, without perceiving any of the injurious effects of lead, and in some cases it has seemed of value as an astringent.

Other astringents, as aluminated copper (lapis divinus), sesquichloride of iron, chloride of zinc, sulphate of cadmium, and acetate of copper have been used to check chronic discharges from the ear. The greatest caution should be observed in the employment of solutions of iron in the ear. They are likely to mechanically obstruct the ear by rusty deposits, and are inclined to irritate and inflame the organ.

The course and consequences of unchecked chronic purulent otitis media are so common and so dreadful that it is proposed to devote the next chapter to their consideration.

[1] See paper by Schwartze, Archiv für Ohrenh., N. F., Bd. 1, p. 34.
[2] Treatise, Roosa's translation, 1869, p. 461.

CHAPTER VII.

COURSE AND CONSEQUENCES OF CHRONIC PURULENT INFLAMMATION OF THE MIDDLE EAR.

WITHOUT doubt, many of the bad results of chronic purulent otitis media are entirely due to bad treatment or neglect. The fatal issue so often seen is not a necessary one, if the case had received even a fair amount of rational and intelligent treatment. This is amply attested by the statements of every one who has paid a little more than ordinary attention to the subject of aural disease. Doubtless, many more of the evil consequences of neglected otorrhœa would be recorded if they were even recognized as such. But, as every aurist knows, meningitis from an extension of an aural inflammation to the brain is by no means rare; yet the records are strikingly meagre, a fact only to be accounted for, either by ignorance on the part of the would-be diagnostician, or his unwillingness to acknowledge the cause and nature of the disease which has proven fatal while under his care. However, long before chronic purulent otitis media has reached its later and alarming stage, although some of its annoying consequences may have shown themselves, it is still curable if it is recognized and properly treated. Now, in addition to the efforts to cure the original disease of the mucous membrane in the middle ear, other endeavors must be made to remove the evil consequences of this chronic inflammation which may have arisen.

Chronic purulent inflammation of the middle ear tends to the production of: 1. Permanent hardness of hearing and deafness. 2. Epileptiform and other nervous manifestations. 3. Granulations and polypi in the ear. 4. Ulceration of the mucous membrane of the tympanic cavity; periostitis; ostitis; caries and necrosis of any or all of the parts of the temporal bone and portions of the adjacent bones; inflammation of the meninges and sinuses of the brain; embolism; cerebral abscess; pyæmia; and death.

1. Hardness of Hearing and Deafness.—Among the earliest consequences of chronic purulent otitis media, is destruction of the sound-conducting parts in the middle ear. This produces hardness of hearing and deafness, both of which are more or less permanent; though in some cases a surprising amount of hearing is regained under proper treatment. Usually, the perforation in the drum-head will close if the mucous lining of the tympanum is restored to health; but if the latter is not gained, or if the perforation of the drum-head be extensive and the ossicles have become carious, necrosed, and destroyed, a permanent diminution in hearing must be expected. The diminution of hearing and the extent of the loss in the membrana tympani and the ossicles do not seem to be in any fixed proportion. Sometimes it is found that a long-continued suppuration in the middle ear is accompanied by a small perforation in the membrana tympani, but that the deafness is great. Again, the perforation may be large and some of the ossicles deeply implicated, yet the hearing is by no means gone. In cases resembling the former it is often found that bleeding and other evidences of granulations in the tympanum exist.

In the latter instances, though the sound-conducting parts are for the most part deeply diseased, the stapes and the mucous membrane round about its foot-plate and the oval window may be in a comparatively normal condition, which allows a free motion of this small ossicle in and out of the fenestra ovalis. At the same time it will be found that the membrane of the round window is intact, and that the delicate parts of the internal ear are quite well protected.

With the two fenestræ thus in nearly a normal state, sound-waves are conducted by the stapes to the labyrinth. Should one or both of these fenestræ become diseased, or should the stirrup become impacted by swollen mucous tissue, in the oval window, then the hearing will be found greatly impaired.

In some instances the stapes has been supposed to be relaxed and thus to fail to convey the undulations of sound to the labyrinth. To support this bone seems to be the endeavor of most surgeons, in applying an artificial drum-head, as is held by Hinton.[1]

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[1] Op. cit., p. 189.

Most eases of chronic suppuration in the middle ear have already undergone great loss of substance in the sound-conducting parts, long before a rational treatment has been instituted. Although, now, by use of means already mentioned when considering the treatment of an uncomplicated ease of chronic purulent otitis media, the discharge may be checked and the progress of the disease in the tympanum arrested, the hearing will usually be found greatly impaired, in consequence of a loss of substance in the sound-conducting parts and their failure in function. If the sound-perceiving parts, the labyrinth and its contents, are in a normal condition, an endeavor may in some eases be demanded and made to substitute the loss in the sound-conducting parts, or to help those portions which still remain, to convey sound-waves to the nerve of hearing in the labyrinth. This is best accomplished by some form of that which is known as an artificial membrana tympani.

Artificial Membrana Tympani.—Contrivances to protect the middle ear in eases of perforation of the membrana tympani, were considered necessary and employed by Marcus Banzer, 1640, Leschevin, 1763, Autenreith, 1815, and Lincke, 1840. In one important sense, these devices were artificial drum-heads, because they were intended to supply the protective function of the natural membrane.

They consisted mainly in short and delicate tubes, over one end of which a thin membrane was stretched and varnished, and then the instrument was worn in the auditory canal. But there is no good account of either an attempt to improve the hearing by their use, or that they even suggested the artificial membranes. In fact they were considered as an impediment to hearing.[1]

As is well known, the first account of an artificial drum-head worn for the purpose of improving the hearing, is that of an American, who, of his own accord and device, thus used a spill of paper. He communicated his invention, and the good hearing he was able to gain for himself by its application, to Dr. Yearsley, of London, in 1841.[2]

The hint thus gained by Dr. Yearsley led him to try pellets of

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[1] Lincke's Sammlung, p. 182, I.
[2] See " Deafness Practically illustrated," London, 1863, p. 221.

cotton instead of twisted paper, since a trial of the latter in other patients invariably failed. His success with cotton-pellets, however, is universally known, and his method used with great advantage at present, in a large number of cases, but with necessary modifications.

Itard, Delean, and Tod, are quoted by Toynbee, as having observed deafness relieved by the introduction of cotton or lint into the external auditory canal, and its contact with the partially destroyed membrana tympani.[1]

Mr. Wilde[2] states that a lady informed him as early as 1845, that she had discovered that she could improve her defective hearing by inserting, down to the drum, a moist pellet of cotton.

Mr. Toynbee, in 1853, suggested the use of a disk of India rubber, to the centre of which was fastened a silver wire by which the artificial membrana tympani could be inserted and adjusted.[3]

Fig. 73.

TOYNBEE'S ARTIFICIAL MEMBRANA TYMPANI.

Politzer[4] subsequently modified this instrument by fastening a wire to one end of a simple strip of thin India rubber, and he has found that it answers nearly if not quite as well as the disk.

In 1867, Dr. Loehner[5] published his improvement in the mode of fastening the wire to the rubber disk of Toynbee's artificial membrana tympani. Instead of holding the disk to the wire by soldering it between two very small metallic plates, the wire was twisted into a double spiral at one end, thus forming two small rings, between which the rubber disk was wedged and firmly held. The inner end of the wire, which would naturally project and irritate the ear, was bent about and pushed into the rubber. Dr. Loehner further suggested the substitution of vulcanized rubber instead of the more pliable rubber sheeting

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[1] Op. cit., p. 160–161.   [2] Op. cit., p. 295.   Amer. edit., 1853.
[3] Op. cit., pp. 161–175.   [4] Wiener Med. Halle, 1864.
[5] Archiv für Ohrenh., Bd. ii. p. 147.

employed in the original instrument, and also the use of thin gold-plated silver wire for the thicker silver wire.

Prof. Gruber's[1] modification consists in attaching a silk thread to a circular disk of thin rubber sheeting. This instrument is to be considered as having less tendency to irritate the ear, and as being more sightly than one in which the wire projects from the meatus. The inventor thinks that the silk thread is less likely than the wire to tear from the rubber membrane.

Dr. A. Hartman,[2] of Berlin, has successfully used a new form of artificial drum-head devised by him. It consists in a very thin piece of whalebone 6–7 cm. long and 1–2 mm. wide, scraped very smooth and specially thin at the central part. When thus prepared, yet still retaining a good amount of elasticity, the whalebone strip is wound round with cotton-wool, and then, after its two ends are brought together, it is so fastened as to form a loop. This simple and apparently satisfactory instrument is inserted either by the surgeon or the patient into the meatus, and adjusted to the proper place on the remnant of the sound-conducting apparatus.

If the loop is made narrower and wound round more thickly with cotton-wool, its action is similar to Yearsley's cotton pellet, but if the loop is broader and not so thickly wound with cotton, it will exercise more pressure on the sound-conducting parts, as suggested by Dr. Hartmann.

Mode of Application of the Artificial Membrana Tympani.—Nothing seems more simple than the direction to pass a small pellet of moistened cotton down the external auditory canal to the membrana tympani; yet to do this, so that the hearing is improved, is by no means easy. The universal statement of those who have used this simple means with success, is that the precise spot, which being touched and rested upon by the cotton, the hearing is improved, must be gently and often persistently sought for. This is best done by the surgeon at first; afterwards, intelligent adult patients learn to apply and remove the artificial drum-head whenever it is needed. Children are in no case to wear one, and, perhaps, the artificial membrane should never be worn in one ear if the function of the other ear is good.

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[1] Wiener Med. Presse, 1874, No. 40.
[2] Archiv f. Ohrenh., Bd. xi. p. 267, 1876.

The cases of perforation of the drum, with little or no discharge, are the best suited for a trial of the artificial membrana tympani. If, however, there is any hypersecretion from the drum or external auditory canal, it should be removed before the artificial drum-head is applied. Then, when the auditory canal, membrana tympani, and the exposed tympanic cavity are illuminated as thoroughly as possible, by means of light reflected from the forehead mirror, the insertion of some form of artificial membrane may be made. Preferably, the early trial should be made with cotton-pellets. One of these may be made, varying in diameter from two mm. to seven or eight mm., and moistened with a little glycerine and water, to which is added by some a little sulphate of zinc. This pellet should then be grasped by the most delicate and slender forceps (see p. 297) and, under good illumination, brought down to the opening in the drum-head. If the stapes is exposed it will be best to place the pellet of cotton at once on it. If the ossicles, or parts of them, are still present and in connection with the stapes, the artificial membrane must be shifted until the proper point of support is reached. But in some, perhaps in many, cases of large perforation of the membrana tympani, no improvement in hearing can be gained after many patient endeavors at placing the artificial membrane.

If Toynbee's rubber-disk-membrane, or its modifications, are to be used, the ear must be illuminated in the same way as just indicated, but these instruments are inserted by means of the silver wire to which they are attached. The same general rules respecting preparatory and continued cleanliness, adaptation of size, and careful manipulation for the right spot must be observed here, and in the use of all other forms of artificial membrane. But it is no easy matter to convey by writing the varied, perhaps endless, ins and outs of the manipulation which is required in the successful employment of an artificial drum-head. Each case must be studied, to a great extent, by itself, only intelligent adults must be chosen for a trial, cleanliness must always be observed, and the effects of the wearing of the membrane most *carefully* watched, for, in many cases, even in the most propitious, the artificial membrane, of whatever form, may prove to be an irritant. The latter feature is their worst. No one should push cotton down the auditory canal unless conscious

that he is doing it with every guard for success. The want of an intelligent adaptation of means and ends has led to barren results and to a general disuse of that which might prove of much greater benefit than generally supposed, if it were but properly used.

Action of the Artificial Membrana Tympani.—That the artificial membrana tympani greatly improves the hearing in many cases is amply shown by the experience of all aurists. How it acts in restoring the hearing has been variously explained. It may be by support, or support and pressure combined, as shown by Yearsley. The latter action would be required in cases in which there is no visible perforation, for Yearsley believed that the artificial membrana tympani was worn with improvement to the hearing in some cases of imperforate membrana tympani, as did Erhard, of Berlin. Von Troeltsch relates such a case too, of a judge whose hearing was improved by pressure on the imperforate membrane, but this action of the artificial membrane is considered doubtful by most authorities of the present day.

If the hearing is ever improved by wearing any form of artificial membrana tympani against or pressed upon the imperforate natural membrane, it can only be explained as was done by Yearsley and Erhard, that, by an inflammation in the tympanum, the incus had become detached from the stapes, and the continuity of the chain of sound-conducting ossicles destroyed, without any accompanying perforation of the membrana tympani. Pressure now exerted upon the natural membrane, and mediately on the ossicles, might bring together the disunited incudo-stapedial joint, and sound-waves be again transmitted to the brain.

The artificial membrane probably does not act by merely stopping the perforation in the membrana tympani, thus confining the vibrations of sound to the tympanic cavity and concentrating them upon the labyrinth, as held by Toynbee.[1]

Moos,[2] Politzer,[3] and Lucæ[4] believe it to be shown that the benefits arising from the application of the artificial drum-membrane are due to intra-aural, *i. e.* labyrinthine, pressure.

Helmholtz, as quoted by Moos, supposes that, in cases in which the stapes is isolated from the rest of the chain, the artificial

[1] Op. cit., p. 161, London, 1868. [2] Archiv f. Ohrenh., Bd. i. p. 119, 1864.
[3] Wiener Med., Halle, 1864. [4] Virchow's Archiv, Bd. 29.

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membrane takes the place of the natural one; or, as Politzer has expressed it, the artificial membrane, by virtue of its large surface, is able to convey to one of the ossicles a quantity of vibrations, which otherwise might be lost in their passage towards the labyrinth. Mr. Hinton[1] believed that "the question whether the artificial membrane operates by closing the orifice in the membrana tympani, or supporting the ossicula, and especially the stapes, is now decided in favor of the latter view," and, accordingly, he made the endeavor to place the artificial drum-head in contact with the head of that bone.

Pressure may indeed be necessary in some instances to restore the hearing, especially if the stapes alone of all the ossicula is left and exposed by the great destruction of the membrana tympani.

But there are cases in which all the ossicula are present and vibratile, the stapes neither isolated from its fellows nor visible through the perforation in the membrana tympani, and the latter largely perforated and *greatly retracted*. Yet in these cases the proper application of an artificial membrane, especially of a cotton pellet, will improve the hearing. In such cases it is very plain that direct pressure on the already retracted drum-head and chain of ossicles would but increase the hardness of hearing, since the latter disturbance is doubtless due to too much labyrinthine pressure by the indrawing of the foot-plate of the stapes. The object of an artificial drum-head should be to overcome this undue retraction of the sound-conducting parts and take off the pressure from the contents of the labyrinth. An important function of the normal membrana tympani is to act as a partial antagonist to the tensor tympani. If this function is diminished, as it most undoubtedly is, if a portion of the membrane is lost and its tension overcome, the tensor acts with undue power, the ossicles are drawn inward, their proper swinging interfered with, and the labyrinth-fluid unduly compressed. The cause of deafness is now very plain, and its remedy indicated in overcoming this retraction of the conducting chain.

If a pellet of cotton be so adjusted that its upper surface or periphery is gently tucked under the region of the tip of the manubrium, it will be found that the retraction is overcome, the chain of ossicles liberated, and the hearing improves.

[1] Op. cit., pp. 189–190.

By bearing in mind that the ossicles of hearing are but a set of jointed bones, and that consequently their function depends upon neither disjunction nor ankylosis, an explanation is the more readily found for the failure in many cases of pressure only, in the application of the artificial drum-membrane.

The Protective Function of the Artificial Membrana Tympani.— In addition to other good results, Yearsley[1] claimed that a pellet of moistened cotton-wool used as an artificial drum-head, would cure an aural discharge.

This function of the artificial membrana tympani is one that has been somewhat overlooked of late. Many an otorrhœa is kept up by the exposure of the tympanic mucous membrane beneath the drum-head, especially in those cases in which the inflammation has commenced in the latter structure. In such cases, by protecting the drum-cavity with a pellet of cotton laid over the perforation in the membrana tympani, a slight discharge which may not have shown any tendency to be checked will cease as soon as the drum-cavity is thus protected. If the perforation be not too chronic, such artificial protection will stimulate the edges of the perforation and favor a rapid closure. This is especially well shown by the use of small paper disks, of sized paper, as first recommended by Dr. C. J. Blake, of Boston.

Respecting the application and results of these paper disks, Dr. Blake writes[2] me as follows :—

" It consists in treating perforations of long standing, where the vibratory power of the membrana tympani and ossicula is not wholly impaired, by covering the opening with a piece or pieces of sized paper wet with water ; the sizing gives sufficient adhesion. The applications generally improve the hearing immediately, and the paper stimulates new growth from the edges of the perforation, and protects it until repair is effected. The new growth, being protected by the paper, is firm and tense, and serves to assist in the vibration of the membrana tympani as a whole, as a lax cicatrix would not do. The paper is then removed by a natural process of repair and growth of the dermoid coat, which I am now making the subject of further experiment, showing a provision, as yet, so far as I am

[1] Op. cit., p. 262.   [2] Boston, April 28, 1876.

aware, undescribed, for the protection of the membrana tympani."

I have tried the use of such disks as Dr. Blake has recommended, and have found them of great service.

2. Epileptiform Manifestations and other Nervous Phenomena in consequence of Chronic Purulent Inflammation in the Middle Ear.

—Chronic suppuration in the middle ear often gives rise to epileptiform manifestations and other nervous phenomena, as irritation of the chorda tympani with permanent facial paralysis, anomalies of taste, and disordered secretion of saliva, alterations in sense and sensibility of the tongue, *temporary* facial paralysis, alterations in gait, like those in Ménière's disease, softening of the ganglion of Gasser, with altered nutrition in the eye, and perhaps, hemiplegia; but, gravest of all, reflex psychoses may be thus brought on.

The epileptiform manifestations occurring as a consequence of chronic suppuration of the middle ear, are to be regarded as reflex phenomena, due to pathological irritation of the sensory nerves of the ear. This is manifest from the record of cases made by Schwartze and Köppe,[1] Hughlings Jackson,[2] Moos,[3] and others.

The subjects of these attacks are usually young persons from 15 to 21 years of age, and so far as recorded, are observed to be of the male sex. The chronic suppuration had, in most cases, continued for a long period, was accompanied by repeated attacks of earache, the growth of granulations in the ear, large perforations in the membrana tympani, and foul discharges from the ear. In most of the cases, attacks of intense earache preceded the epileptiform seizure, and in one case, that given by Schwartze, there was precordial discomfort and a well-marked aura in the ear several hours before the fit. In this case, too, the headache was intense, but gradually located itself in the mastoid region, the gaze then became fixed, and twitchings in the region in front of the ear supplied by the facial nerve, would usher in unconsciousness. The predisposition to these attacks may last for

[1] Archiv f. Ohrenh., vol. v. p. 282, 1870–72.
[2] British Medical Journal, June 26, 1869.
[3] Archives of Oph. and Otol., vol. v., 1876.

several years and then disappear if the disease in the ear is lessened or removed. They occur in conjunction with chronic suppuration in one or in both ears. These seizures have been observed to occur first at night (Köppe and Hughlings Jackson), then in daytime; they come on at irregular intervals usually, though they may appear as often as two or three times daily, as observed by Köppe in an idiot boy in whom for ten years both ears had been seriously diseased after scarlatina. In the case of a boy 12 years old, observed by Hughlings Jackson, a chronic discharge set in after scarlatina; nine months later facial palsy was noted, but this disappeared, and three months later, one year from the beginning of the aural disease, the first epileptoid seizures occurred at night. "It wakes him up, he feels giddy, he loses his sight, and does not know what he is doing. He then goes into the fit, struggles, and foams at the mouth; he does not bite his tongue; next day he is seemingly well."

Causes.—These epileptoid seizures may be due to minute changes in tracts in the brain which give rise to occasional discharges of nerve force, as held by Hughlings Jackson. Although it is not known what cerebral region is affected, it may be found that these seizures are due to instability of those regions of the brain in which disease of the ear sometimes leads to abscess, a view also advanced by the same observer. One thing is very certain, that peripheral irritation in the ear is known to be the cause of a number of previously unrecognized reflex nervous phenomena. In some instances the cause of the epileptoid symptoms has been supposed to be due to irritation of the tympanic plexus from inflammation in the tympanum, as shown by Moos. "This condition of irritation communicated itself to the brain and produced there the described attacks, which were favored by an hereditary tendency."

In some instances, epileptoid symptoms, or at least conditions of more or less sudden unconsciousness, occur in those affected with great naso-pharyngeal catarrh and catarrh of the Eustachian tube, unattended with chronic purulent discharge from the tympanum. In such cases there are always evidences of increased swelling of the mucous membrane of the mouth of the tube, closure of the latter, and indrawing of the membrana tympani and the chain of ossicles. This, by carrying the foot-plate of the stapes further inward, causes increase of intra-laby-

rinthine and cerebro-spinal pressure, and the unconsciousness.
If vomiting occurs, as in the case described by Moos, or if infla-
tion of the tympana be effected, as in a case recorded by Erhard,
the attack is ended, for the closure of the tube is overcome in
the first instance by relaxation of the mucous tissues, and in
the second, by the mechanical effect of inflation, which draws
the foot-plate of the stapes from the deep position in the oval
window.

Treatment.—It is almost needless to say that the treatment
should consist in the endeavor to remove the cause of irritation,
especially if these seizures are to be regarded as reflex in origin.
Hence, in Schwartze's case, recovery ensued upon trephining the
mastoid ; in Köppe's case by both constitutional and local means.
Belladonna and a seton are classed by him under the first head,
and under the second he places the treatment of the diseased
mucous membrane in the ear.   By this means the "vulner-
ability and reflex excitability" of the brain and the peripheral
irritation are combated.   In Moos's case the epileptiform symp-
toms were allayed by appropriate treatment of the mucous
surfaces in the ear.   Even reflex mental diseases may be cured
by proper treatment of the middle ear and naso-pharynx, and,
in one instance, symptoms of intense headache, sensitiveness
of the scalp, and the most melancholic psychical disturbances
were entirely and almost immediately relieved by removing
hardened blood-clots from each external auditory canal, where
they had remained for years after a fall, in which hemorrhage
into, if not from, the ear had occurred.

*Various Nervous Phenomena produced by Chronic Purulent Otitis
Media.*—Prof. Moos[1] observed a case of chronic purulent dis-
ease of the midddle ears, in which alterations of sense and
sensibility in the tongue were produced by the application of
an artificial membrana tympani to each perforated drum-head.
Since these phenomena were due to pressure on the diseased
membrana tympani, and mediately on the chorda tympani, an
important deduction to be drawn from this case, as Moos states,
is that the chorda tympani contains and transmits not only
fibres of taste, but also those of common sensibility.   Dr. Carl[2]

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[1] Archives of Oph. and Otol., vol. i. pp. 140-148, 1869.
[2] Archiv f. Ohrenheilk., Band x. p. 152.

has described phenomena of altered sense of taste, occurring in himself, in consequence of chronic purulent otitis media, which were probably due to destruction of the chorda tympani.

The coincidence of *hemiplegia* with chronic and neglected suppuration of the middle ear has been pointed out in two cases by Roosa,[1] and their possible causal relation suggested. The one case was that of a boy, ten years old; the other, a farmer, sixty-two years of age; though inclined to regard the former case as one of coincidence, Dr. Roosa regards it as probable "that a blood-clot might readily form between the dura mater and the bone, from rupture of the middle meningeal, in the existence of caries of the temporal bone, and hemiplegia be induced by pressure communicated to the motor tract, or, as Mr. Hutchinson says, as quoted by Hughlings Jackson,[2] by squeezing the blood from the corpus striatum or thalamus opticus."

Paralysis of the Facial Nerve.—Paralysis of the facial nerve is not a common occurrence in chronic suppuration of the middle ear, but if it occurs with necrosis of the temporal bone it is very apt to be permanent. During chronic suppuration of the ear, however, temporary paralysis of the facial nerve may appear. Such attacks of palsy may be referred to temporary congestion and an acute inflammatory process in the middle ear, in addition to the already existing chronic disease. *Temporary palsies* of the parts supplied by the facial nerve occur in perfectly healthy ears which have become the seat of acute inflammation, and are probably due to congestion, especially in children, and to pressure of accumulated secretion, as shown by Gruber.[3] That such palsies may occur, and probably by an acute process, in a chronically suppurating ear, is shown in the following case:—

The patient, a lad of fourteen years, stated that he had had a neglected aural disease ever since childhood. Some weeks previous to the time I first saw him, August, 1874, he had been attacked by severe pain in the left ear, after bathing in the sea, at Cape May, where he was employed. He then came to Philadelphia to obtain relief from the terrific pain in the ear, and

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[1] Transact. Amer. Otol. Soc., vol. i. p. 118, 1870.
[2] Reynold's System of Medicine, vol. ii. p. 505.
[3] M. f. O., No. 10, 1873.

applied to Dr. A. D. Hall, who made a deep incision over the mastoid process, giving vent to a large amount of exceedingly offensive pus, and relieving greatly the suffering of the patient. The next day Dr. Hall sent the boy to me. I found the lad very weak, with a pulse over 100, forehead bathed with clammy perspiration, anorexia, less pain since the mastoid incision, with considerable vertigo, and an offensive purulent discharge from the ear and the incision over the mastoid process. I found that a probe entered over the mastoid process point-blank, three-fourths of an inch, coming in contact with dead bone. There was also a sinus running from the external auditory meatus, upward and backward, to dead bone in the mastoid cavity. The patient stated that about a year previous to this time a piece of dead bone had worked its way from the auditory meatus, after an attack of pain in the ear. A probe, passed through the sinus in the auditory canal, and another passed through the sinus behind the auricle, could be made to touch each other in the mastoid cavity, and dead bone was felt everywhere in their path. The silver probe passing into the sinus running from the auditory meatus became instantly blackened, and from this sinus crumbs of black and offensive bone were constantly discharged, for several days. At the point in the auditory meatus where the probe entered, there was a large bunch of granulations, which was finally removed by a wire-snare. I could not detect any sequestrum at that time. I placed the boy in the Presbyterian Hospital, and gave him milk-punch and tincture of chloride of iron thrice daily for several weeks, during which period the pain became very much less in the ear; that which he still experienced was above, and running forward from the auricle. The vertigo disappeared, and the patient was able to take muscular exercise; the ear became less tender, and permitted all necessary manipulation, but the patient could not lie on the ear in bed. Under this treatment the discharge grew less, and on the 24th of September I extracted, through the opening in the mastoid process, a spongy sequestrum one-half inch square, and then, placing the broad, blunt nozzle of a syringe in the opening, I gently injected a stream of warm water, which washed out a copious amount of large cheesy-looking masses through the external auditory meatus, and some portions of the mass, passing through the Eustachian tube, escaped by the

month. The masses were composed of large acicular crystals of cholesterine and fatty epithelial débris, and strongly reminded one of the matter found in cholesteatoma of the ear, as described by Lucæ.[1] The removal of the sequestrum and the subsequent syringing, with its fruitful results, gave still further relief to the patient; all pain disappeared, and he could now lie on the ear in bed.

The sinus behind the auricle closed in four days after the removal of the sequestrum, and in a week from that time the discharge from the ear had almost ceased, and the odor of diseased bone, which had pervaded the patient, had disappeared; but I could still feel *loose* crumbs of dead bone lying in the sinus leading from the auditory meatus to the mastoid cells. Therefore, I widened the sinus with my knife, cutting from the meatus towards the mastoid process, and inserted a tent in the widened sinus. The tent was reinserted; for five days crumbling bone came away, the odor and discharge lessened, and the sinus in the meatus closed October 17, under instillations of a solution of sulphate of copper (3 gr. to f℥j). The patient had become by this time quite strong under the constant use of tincture of chloride of iron, and, occasionally, alcoholic stimulants.

During the night of the 19th of October, four weeks after the removal of the mastoid sequestrum, the patient experienced some pain in the ear, but not enough to keep him awake. On the morning of the 20th, he found that " he could not whistle," and that the tears ran over his left cheek constantly. Facial paralysis became fully established on the left side by the 21st; so much so that food lodged between the cheek and teeth on the affected side. There was no continuance of pain, and the patient expressed himself as feeling very well. He took, without my consent, a situation offered to him, and went to work at this time, the paralysis disappearing in two weeks, as I learned subsequently, for I did not hear from him until nine months later, when he visited me, and I found him entirely free from paralysis and all aural discharge. He had continued, on his own responsibility, to take the tincture of the chloride of iron until the paralysis had disappeared.

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[1] Archiv für Ohrenheilk., Bd. i. No. 1.

Facial paralysis is not of frequent occurrence in necrosis of the mastoid process, but if it occurs it is likely to be permanent. Its permanence is due to the erosion of the Fallopian canal, and an organic lesion of the facial nerve. Its occurrence and subsequent disappearance in this case is of interest, and worthy of consideration. It can be explained, I think, as follows:—

1. It is well known that the facial nerve will resist the chronic inflammation attacking the petrous bone, long after the Fallopian canal is destroyed. Gruber has reported a case, with an engraving, in which the facial nerve was exposed for two-thirds of its length in the tympanum, by necrosis of the Fallopian canal, and yet no paralysis ever occurred (*Lehrbuch*, p. 541).

2. It is, therefore, probable that, the facial nerve becoming unduly exposed, in the case I have described, by caries of the Fallopian canal, a slight acute inflammation in the middle ear furnished pressure sufficient to produce the functional paralysis. The disappearance of the paralysis was of course due to the absorption of the products of the acute inflammation, from which it may be learned that, alarming as paralysis of the facial nerve is in *necrosis of the mastoid cells*, it is not necessary when it occurs, to give an unfavorable prognosis, for it may be, as in this case, simply a temporary paralysis, due to pressure from an effusion of fluids, which can soon become absorbed and permit the nerve to resume its function.

Alterations in Gait.—In connection with chronic suppuration of the middle ear and caries of the petrous bone, Dr. Tédonat[1] observed peculiar alterations in gait, by which the patient was made to pursue a curved line in walking, and, at the same time, was inclined to turn about his vertical axis from the affected towards the well side. There was at the same time facial paralysis, softening of the ganglion of Gasser, and altered nutrition in the eye. Post-mortem examination revealed destruction of the semicircular canals in this case.

Irritation of the Chorda Tympani.—Dr. H. D. Noyes[2] has given an account of irritation of the chorda tympani produced very probably by disease in the tympanum. The patient, a physician

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[1] Lyon Médical, No. 26, 1874; also abstract by Schwartze, A. f. O., Bd. x. p. 256.

[2] Transactions American Otol. Soc., vol. i. p. 556, 1875.

33 years old, stated that at the early age of one year and six months, he had an abscess in his ear, but exactly in what part of the organ he could not tell. A discharge was thereby established in his ear, attended with perforation of the membrana tympani, impaired hearing, and constant tinnitus aurium. This condition prevailed until the patient's twenty-third year, when the discharge became somewhat altered in its appearance, and subject to variations in amount. About this time the perforation in the membrana tympani is supposed by the patient to have closed. About the same time a feeling of "weight, pressure, of obstruction, and of distension affected the entire left side of the head." Not long after this the patient states that the chorda tympani nerve began to manifest symptoms of irritation. Morbid sensations of taste were easily excited by pinching the pinna, or by stroking the left side of the face with the tip of the finger. This phenomenon, at first paroxysmal, at last became permanent without any external exciting cause. The flow of saliva has been proportional to the amount of irritation. Large portions of it have come from Wharton's duct, but the left parotid gland also secretes more abundantly than the right. Latterly, that is about ten years after the supposed closure of the membrana tympani, facial paralysis was suddenly developed, and has remained constant.

When Dr. Noyes inspected this case he found complete paralysis of the left side of the face, including the forehead and orbicularis oculi; the mouth was drawn to the opposite side; the tongue was protruded straight, and its mobility was perfect. The external auditory canal was large and straight, and the membrana tympani was nearly flat, tense, white, and thick, not vascular. Seated upon its upper and middle portion was a polypoid growth as large as a pea, firm to the touch, red but not disposed to bleed. "*The slightest touch of it, though not painful, excited sensations in the tongue.*" The auditory canal contained a moderate amount of pus, the Eustachian tube was pervious, and the tympanum easily inflatable; hearing reduced to contact. The polypus was removed; the membrana tympani assumed an appearance which did not seem to indicate the presence of granulation-tissue in the drum-cavity, and there was no perforation. The discharge ceased, the hearing improved, and the disagreeable head-sensations disappeared. Dr. Noyes states that the

polypus sprang from the handle of the malleus, and his expla-
nation of the peculiar symptoms of irritation, is that "this bone
had been the seat of chronic inflammation, involving its sub-
stance and periosteum, and which had caused the irritation of
the chorda tympani." That the cause of the irritation in this
case was in the middle ear, as well as in the membrana tympani
(malleus), is fully shown by the facial paralysis.

It must be borne in mind that the chorda tympani has no part
in the nervous function of the tympanum; it is only on its way
in the tympanum from the facial nerve to the tongue (see p. 89).
This branch of the facial is, of course, liable to be injured by
morbid processes in the tympanum, but it is in no physiological
way connected with the functions of that cavity any more than
the facial nerve is, as it passes through the Fallopian canal in
the posterior part of the same cavity. In many respects the
name chorda tympani is unfortunate, as it would naturally sug-
gest a nerve of more than ordinary importance to the drum-
cavity.

*Anomalies of Taste and Salivary Secretion in Chronic Purulent
Disease of the Tympanum.*—The sense of taste, as well as the
secretion of saliva may be altered, either diminished or increased,
by the presence of chronic purulent disease in the cavity of the
drum. Dr. Urbantschitsch[1] found, in an examination of fifty
individuals affected with chronic purulent disease of the tym-
panum, that the sense of taste is most highly developed in the
region of the posterior wall of the pharynx, the uvula, the
arcus palato-glossus, the base of the tongue, and on the mucous
membrane of the cheek. In forty-six individuals, anomalies of
taste were discovered: only in four cases, of purulent disease
on one side, was the sense of taste undisturbed, remaining equal
on both sides. In thirty-eight cases the taste was diminished,
three times abnormally increased; in five cases it was in some
respects increased and in others diminished; thus in a case of
chronic purulent disease in the right ear the sense of taste for
salt and bitter substances was impaired, while it was augmented
for sweets and acids. Besides these disturbances of taste, there

[1] Ueber Anomalien der Geshmaksempfindungen der Speichel Secretion in
Folge eitriger Erkrankung der Paukenhöhle, Gesellschaft d. Aerzte in Wien.,
21 April, 1876. Wiener Med. Presse, No. 23, 1876. M. f. O., No. 10, 1876.

was in twenty-four cases a blunted sense of touch ; in six cases, though the sense of taste was lost on the affected side, the sense of touch was normal.

The causative effect of the purulent disease in the ear is confirmed by the fact that in many cases the anomalies of taste and touch vanished with the healing of the ear. The chorda tympani and the plexus tympanicus are to be looked to for the explanation of these changes. In addition to the above changes, anomalies in the secretion of saliva have also been noted by Dr. Urbantschitsch ; in one instance where a polypus was situate near the upper part of the tympanum, and in other cases, after various powders had been blown into the ear, and the tympanum had been touched by nitrate of silver. In the first instance the stimulation is supposed to have been brought about through irritation of the chorda tympani, and in the other cases by excitation of the lesser superior petrosal nerve, the influence of which over the parotid was distinctly and directly observed on a patient. These clinical observations of Dr. Urbantschitsch appear to be in harmony with the experiments of Cl. Bernard, Schiff, Ludwig, and others.

Vertigo in Chronic Purulent Disease of the Middle Ear.—It sometimes happens that well-marked symptoms of aural vertigo occur in chronic purulent disease of the middle ear. But I have not found this to be common. The following case will illustrate, however, its occurrence. A. B., age 18 years, student in classics, has had purulent disease of both ears from scarlatina in infancy. On the right side, the membrana tympani is destroyed and the hearing gone. The discharge has become very slight. On the right side, the membrane is perforated. The mucous membrane of the tympanum is thickened over the promontory. Hearing for moderate speech 4 paces. The discharge is slight on this side. Jan. 1877, the patient states that a day or two ago, while in the lecture-room, he was suddenly seized as never before, with a roaring in the left ear, which was followed by nausea, dimness of vision, giddiness, and faintness, but he was able to leave the room unaided, and went home. While riding home the symptoms all vanished, and within fifteen minutes he felt quite well. In this case the lesion must have been in the middle ear, but the dizziness, etc., were probably due to an irritation extended

to the labyrinth, from pressure by an over-accumulation of secretion in the tympanum.

Reflex Psychoses from Chronic Purulent Inflammation of the Middle Ear.—Quite recently, Köppe[1] published an account of two cases of reflex psychoses, in one of which the mental disorder was in all probability excited and kept up by chronic purulent otitis media. In the other case hardened blood-clots in each external auditory canal were very plainly the exciting cause of the insanity. In both of these men, though possessed of an hereditary tendency to insanity, and having been exposed to violence on the head, by falls and blows, the mental disorders, melancholia with tendency to murder and suicide, were entirely relieved by treatment applied to the ears and the chronically inflamed nares and naso-pharynx.

3. Granulations and Polypi.—Purulent inflammation of the middle ear may lead rapidly to the formation of granulations and polypi. These results are, however, the more likely to be found as a consequence of neglected and chronic suppuration of the tympanum. According to my observation, granulations are less common than distinct and solitary polypi. The former may appear quite soon after a purulent process has been established in the middle ear, and may be attached either to the mucous membrane of the tympanum, the membrana tympani, or to the walls of the auditory canal.

Upon inspection of an ear in which granulations have sprung up, the view obtained will depend upon the size and quantity of these growths. When growing on the mucous membrane of the tympanic cavity, they will give to it a roughened and granular appearance, very readily seen if the perforation in the membrana tympani is large, and unobstructed by granulations. The latter may grow on the edges of, or near the perforation, on the mucous side of the drum-head. If granulations have also sprung up in the auditory canal, these may obstruct all further view of the membrana tympani and tympanic cavity. All granulations should be considered as incipient polypi.

Polypoid Hypertrophy of the Mucous Membrane of the Middle Ear.—Wendt[2] has described under this term, elevations of the

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[1] Archiv f. Ohrenheilk., vol. ix. p. 226, 1875.
[2] See review by Von Troeltsch, Archiv f. O., Band ix. p. 119.

muco-periosteal lining of, the middle ear, which occur very frequently in exudative inflammations, and are characterized as exceedingly small polypi in their structure. In rare instances these prominences may assume a fold-like elevation, but more commonly these bodies possess a thread-like, or villous form, as well as a finger-shape. They may also be spherical or ovoid in shape, and are attached either by a long pedicle or by a broad strip to the mucous membrane. Sometimes they constitute extensive lobulated masses. The size of these prominences and villi is very varied, reaching in the larger ones a size of 1 mm. According to their composition, these prominences are shown to be proliferations of the subepithelial layer of mucous membrane. A direct participation in them of the periosteal layer could not be found, nor could a corresponding elevation in it be detected. In the spaces between the network of connective tissue, numerous cells resembling lymph-corpuscles were found. The epithelium was sometimes cubical, and, in some instances, cylindrical, both kinds often being found in the same microscopic section. The same kind of miniature polypi were found on the inner surface of the membrana tympani by Wendt.

The mucous membrane of the tympanic cavity is in any case predisposed to hyperplastic processes, and to the formation of rugous elevations and firm projections. By continued growth and constant enlargement these formations may entirely fill up the tympanum, and, after perforation of the membrana tympani, fill the entire auditory canal. They may also cause flat, bridge-like adhesions to form between the membrana tympani, auditory ossicles, and the walls of the tympanic cavity. Cystic cavities may be formed by the union of several elevations with each other. By degeneration and exfoliation these polypoid growths may disappear. Spontaneous degeneration is brought about in these cases by deposition of fat, or by hemorrhages; the vascularity of these growth greatly predisposes to the latter mode.

The pathological alterations in the veins and lymphatics of the mucous membrane of the tympanum, in cases of chronic purulent discharge with perforation of the membrana tympani, have been described by Prof. Politzer.[1] These changes chiefly

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[1] Studien über Gefässveränderung in der erkrankten Mittelohrauskleidung, A. f. O., N. F., Band i. p. 11.

consist in dilatation. In some instances the veins, especially on the inner surface of the mucous membrane, covering the promontory, are greatly widened, very tortuous, with here and there large dilatations.

Prof. Politzer concludes that in chronic inflammation of the lining of the drum-cavity, large numbers of new vessels are formed. The walls of the bloodvessels are often opaque and thickened, being infiltrated with a granular exudation, and pigmented; or, in other cases, the vessels may be filled with blood-globules, while the walls are thinned at some points, and consequently dilated here and there.

The changes in the lymphatics of the mucous membrane of the tympanum are much less common than the alterations in the bloodvessels. The altered lymphatics have been found by Prof. Politzer in new connective-tissue growths in the cavity of the drum, when affected by chronic purulent inflammation.

Treatment of Granulations.—Since granulations are very often the result of poulticing in the acute stage of an inflammation in the ear, it should be said again that all such treatment as contains any of the elements of heated moisture, must be avoided in the endeavors to cure granulations in any part of the ear. The ear should be kept scrupulously clean by syringing, to be repeated as often as is necessary to gain this object. Then some form of astringent or caustic should be applied. An endeavor may also be made to remove, by evulsion, the large granulations, if they can be gotten hold of with convenience to the surgeon and without pain to the patient. But it is not absolutely necessary to thus remove granulations from the ear. They may be pencilled with solutions of nitrate of silver (60–100 gr. to f℥j) or with chloro-acetic acid, and with chromic acid in concentrated solutions. These applications are best made by means of a small tuft of cotton on the cotton-holder; great care should be taken to have not too much of these fluids on the cotton, but just enough to paint the growths without causing any surplus of fluid to be squeezed out and run upon other parts of the ear, as soon as the cotton-tuft is brought into contact with the granulations. Prof. Politzer has caused granulations in the ear to disappear by bringing in contact with them crystals of sesquichloride of iron. The ear is then gently packed with cotton and allowed to remain so twenty-four

hours. While I have seen granulations thus treated, rapidly disappear, I have also produced some inflammation and considerable pain in the ear.

Aural Polypi.—The term polypus is a relic of the older nomenclature, which classed new growths according to their form or general appearance, rather than their structure. The term must have been suggested simply by the ragged, many footed or many rooted appearance of the surface of a new growth, when torn off by a ruder surgical procedure than that in vogue at present. The term "many-footed" of the days of Celsus and others, was analogous, perhaps, to the term "roots" of the present day, both terms being suggested simply by a physical appearance of that part of the growth once attached to the body. The name polypus was originally applied to all tumors which, originating by means of a distinct pedicle from the inner surface of any cavity of the body, projected at last as an independent growth into the same.

Aural polypi presuppose the existence of a purulent process in the ear, attended with the formation of granulation-tissue, the latter being the essential structural nature, in most cases, if not in all, of these growths, as shown by Billroth,[1] Roosa,[2] and others. By a subsequent development of this granulation-material, aural polypi become independent but benignant tumors.

Classification.—Aural polypi may be classified into four varieties, viz: 1. Mucous polypi; 2. Fibromata; 3. Myxoma; and 4. Angioma. The first three are the classification of Steudener;[3] the fourth variety has been described by A. H. Buck.[4] The latter two varieties have been observed only once; myxoma by Steudener, and angioma by Buck.

Mucous polypi are by far the most common in their occurrence, of all aural polypi. The fibromata stand next in the order of frequency. Mr. T. Whipham found, in an aural polypus removed by Mr. Dalby, elements resembling those of round-celled sarcoma.[5]

[1] 1855, see Roosa, op. cit., p. 389.
[2] Op. cit., p. 329, and American Medical Times, August 6, 1864.
[3] Archiv f. Ohrenh., Bd. iv. pp. 199–212.
[4] Transactions Amer. Otol. Soc., 1870.
[5] See "Diseases and Injuries of the Ear," Phila., p. 156.

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Aural polypi vary greatly in their size, shape, color, and consistence. Their average *size* is that of a small bean; Steudener has recorded one, the length of which was 3 cm., and the greatest width of which was 1½ cm. They not uncommonly exceed an inch in length. Their usual *shape* is more or less club- or pear-shaped, though they may assume a spiral, sigmoid form corresponding in general to that of the external auditory canal. The bony canal is rarely altered in shape by them, but they not uncommonly cause a widening of the cartilaginous part of the meatus. The *surface* of the long, club-shaped polypi is usually pale and smooth. In some instances, polypi have a red and lobulated appearance, like a raspberry. Their consistence varies from the dense hardness of the fibroid, to the softness of the gelatinous myxoma, the former being the commoner. The surface of the polypus projecting from the meatus may become ulcerated from the action of the secretion, the atmosphere, and the picking of the patient.

Epithelium is found on all aural polypi; ciliated cylinder-epithelium on their inner end surfaces, pavement epithelium on their outer surfaces. It is the latter which finally may resemble epidermis. Aural polypi are almost invariably attached to the mucous membrane of the tympanum, it being a rarity to find them attached to the auditory canal with an imperforate drum. I have seen but two cases in which the latter feature characterized the growth.

Polypi may be situated in the mastoid antrum and cells, as has been shown by Eysell,[1] in the case of a male child four years old, who had died of pharyngeal diphtheria.

Dr. Borberg[2] found the malleus entirely imbedded in a large polyp removed from the ear. Whether the polyp grew from the malleus, was not determined. A polypus with a cartilaginous base, apparently attached to a bony diaphragm in the external auditory canal, is reported by Dr. O. D. Pomeroy.[3]

Histology.—Mucous polypi, according to the investigation of Steudener, consist of a stroma of fibrillated connective tissue of varied arrangement, containing mucin. Lying in this stroma are a few spindle-shaped and stellate connective-tissue cells, with a distinct nucleus. In addition to these are numerous round,

[1] Archiv f. Ohrenh., Bd. vii. p. 211, 1873.   [2] Ibid., p. 55, 1873.
[3] Trans. Amer. Otol. Soc., p. 541, 1874.

granulated cells with a round nucleus. These cells are either separate or in clusters. The cellular element of polypi is richest in the deeper parts of the growth ; the fibrillated structure composes the superficial portions in which the spindle and stellate cells are in excess of the round cells.

The surface of a mucous polypus is not entirely smooth, since, in the smoothest, a few papillæ will be found projecting far enough into the outer epithelial layers to give this surface a slight roughness. The papillæ are usually richest at the inner end of the polypus. In some instances, however, the red, papillary structure extends throughout the growth and gives it a characteristic raspberry-like appearance.

The quantity of bloodvessels varies in these growths: sometimes the vascular supply is very great. The outer portions of the growth may be very sparsely supplied with vessels, while the deeper parts may contain a generous vascular distribution. As a rule, the large vessels run down the centre and send off branches toward the surface. The investigations of Steudener have shown that mucous polypi are covered with cylinder-epithelium on the inner portions, and with tesselated epithelium on the more exposed, outer surfaces. Also, that in the central portions of these growths there are glandular structures and cyst-like spaces. The latter were first described by Meissner,[1] as quoted by Steudener.

Fibromata.—These growths are characterized by their toughness and their general freedom from a papillary surface. They are covered with several layers of pavement-epithelium. Histologically, they may be said to be formed chiefly of a dense connective-tissue stroma, containing numerous spindle-cells and stellate connective-tissue corpuscles, which form an anastomosing network. The intercellular substance varies even in the same polyp, as shown by Steudener; it may be either entirely homogeneous or coarsely fibrillated. The bloodvessels are always much less numerous than in the previously described variety of aural polyp. Hence, their pale color. They contain no glands nor cystic cavities. They are said by Steudener to be free from mucin, nor has he discovered in them calcareous deposits, as were described by Klotz.

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[1] Zeitschr. f. Rationelle Med., p. 350, 1853.

Myxomata.—In only one instance has a myxomatous aural polyp been described, and that was by Steudener. It was found in the ear of a young man seventeen years old. It was very gelatinous in appearance and consistence. Its surface was covered with pavement-epithelium. The stroma consisted of an entirely homogeneous, gelatinous mass traversed by a delicate network of anastomosing spindle and stellate cells. The gelatinous mass was composed of mucin, in which were a few lymph-cells.

Angioma.—"Angioma is a circumscribed tumor, made up chiefly of newly-formed vessels, or vessels in whose walls are newly-formed elements." Its occurrence throughout the body is not uncommon, but an aural polypus of this nature has been described only by A. H. Buck. It grew in the ear of a lad, 19 years old, who had suffered for twelve years with chronic purulent discharges from both ears. He had also noticed a humming, pulsating noise in his left ear, from which there finally occurred a hemorrhage during the night. The pillow upon which his head had rested, was covered with blood. There was no pain, but oozing of blood continued all day from the ear. The new growth looked dark, and was found to be attached by a long pedicle to the manubrium of the malleus. The pedicle was snipped by Dr. Weir, and the growth examined by Dr. Buck. "The entire mass consisted of bloodvessels, radiating from an irregularly-shaped central cavity, and separated by a network of fibrous connective tissue holding blood corpuscles in its meshes." Six weeks later a second growth occurred, which is considered by Dr. Buck a proof that an angioma is an independent new growth of vessels, as held by Virchow.

Perhaps under this head should come a so-called "venous blood-sac" (venöser Blutsack), observed by Dr. A. Magnus[1] on the inner tympanic wall, in about the position once occupied by the malleus, in an adult male, who had suffered with otorrhœa since childhood. The new growth was the size of a pea, bluish, opaque, quite smooth, and reflected the light like a glass ball; when touched by the probe, it felt like a sac filled with fluid. Incision caused the escape of some dark venous blood, and in a few days the sac shrivelled and disappeared.

Two rare forms, epithelioma and a clot of blood in process of

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[1] Archiv f. Ohrenh., Bd. ii. p. 42.

organization, have been described by Kessel.[1] The former was seated in the external auditory canal; the second grew from the tympanic cavity.

An Organized Vesicular Polypus, containing the Necrosed Long Process of the Incus.—After the removal of a mucous polypus as large as a pea, from the left ear of a boy seven years old, an inmate of the surgical ward of the Presbyterian Hospital in Philadelphia, I discovered a bright red body, which, at first sight, I supposed was a clot of blood. I gently pulled it out, when I discovered it was an organized vesicular body, containing apparently fluid blood, and a small hard substance imbedded in it. This proved to be a portion of one of the auditory ossicles, and upon its being subjected to examination by Prof. H. Allen, of the University of Pennsylvania, it was pronounced by him to be the *long process of the incus*. The vesicle-like polypus, when placed in a mixture of equal parts of water and glycerine, gave up its blood, but retained a membranous, sac-like appearance, though pale and flaccid.

Symptoms.—It cannot be said that there is any special train of symptoms which betray the presence of an aural polypus. Wherever a chronic purulent discharge from the ear has existed a long time, the presence of a polypus may be suspected, but the usual symptoms are only those of chronic otorrhœa. In rare instances, aural polypi may be productive of hemiplegia, as shown by Schwartze.[2] In such instances it is supposed that retention of pus, inducing a severer inflammation in the tympanum, causes a hyperæmia of the meninges of the brain. In the case given by Schwartze, there was incomplete hemiplegia on the corresponding side, together with anæsthesia and ptosis, without facial paralysis. Removal of the polypi caused the above symptoms to vanish.

Hemicrania, sensations of fulness, vertigo, retention of pus, nausea, and vomiting have been observed as results of the presence of a large, obstructive polypus in the auditory canal; but they are not to be regarded as characteristic of the presence of polypi generally. The vast majority of aural polypi are discovered by the surgeon when the patient applies for relief from an aural discharge, the latter being the only symptom.

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[1] Archiv f. Ohrenh., Bd. iv. p. 185.   [2] Ibid., Bd. i. p. 147.

Spontaneous Detachment of Polypi.—Polypi sometimes become detached without any greater application of force than syringing. In some instances they undergo what is termed spontaneous detachment. Schwartze[1] observed two such cases; one, the detachment of a mucous polypus; another, that of a sarcomatous growth. He also quotes Saissy, Toynbee, and Kramer as having observed similar occurrences.

In two instances I have observed the detachment of small polypi by syringing: one, from the wall of the meatus; another, from a small opening in the posterior-superior quadrant of the drum-head. In the former case, a discharge had lasted for a long time, much to the annoyance of the patient, a lady twenty years old. The discharge ceased, and the perforation closed as soon as the polypus was washed out. In the second case there was no perforation of the drum-head. The small polypus, I am disposed to regard as the result of a furuncle in the canal.

Treatment of Aural Polypus.—The treatment of an aural polyp *begins* with its removal. The after treatment of the ear, and especially of the point to which the growth was attached, is as important as removing the polypus. The patient should be told this and enjoined to persevere, after the evulsion of the growth, with the subsequent local treatment of the ear. Unless this is properly and thoroughly done, it is almost useless to remove the polypus, for the patient will at least have undergone some annoyance and pain by the extraction of the growth, and, after a short freedom from it, a new one will spring up. Many patients are deterred from undergoing the removal of an aural polyp because of their fear of a renewal of the growth. This will, indeed, happen if, after the polypus is removed, the point of attachment is not treated, but if the after-treatment is properly gone through with, no fresh polypus will grow from the point of previous attachment, and, furthermore, the tendency to their formation anywhere in the ear, will be removed.

The best instrument for the removal of an aural polyp is Wilde's[2] snare, or Blake's[3] modification of it. Wilde's instrument consists of a fine steel stem five inches long, and bent in the middle. It is provided with a movable bar which slides on the square portion of the shaft near the handle, which latter

[1] Archiv f. Ohrenh., Bd. ii. p. 9, 1867.
[2] Diseases of the Ear, Phila., 1853, p. 397.
[3] Arch. of Oph. and Otol., vol. i. p. 435, 1870.

part fits over the thumb.   At the distal end there is a button-like projection perforated by holes running parallel to the stem, one on each side of it.   There are also two small rings at the angle.   Through these a fine wire of silver, platinum, or iron, or a strand of Jack-line or fishing-gimp (Hinton) may be drawn to form a small loop or noose at the point, while the ends of the wire, or whatever is used to form the snare, are coiled about the crossbar at the handle.

Fig. 74.
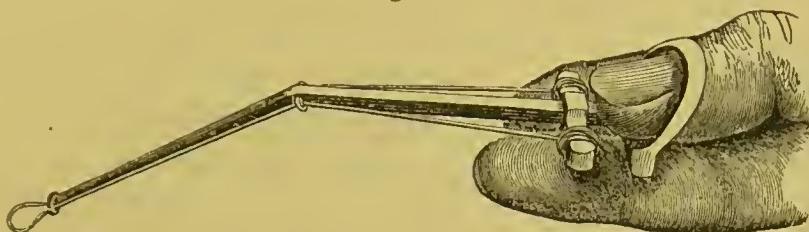
WILDE'S SNARE.

When the instrument is in order, the crossbar may be at any point on its part of the shaft, most convenient to the surgeon. I prefer to have it rather nearer the angle than the handle.   By traction on the crossbar, the loop at the end is narrowed and the polypus or its pedicle constricted.

Blake's modification of the valuable instrument of Wilde consists chiefly in causing the wire, left bare between the point and the angle in the shaft, to run in a miniature barrel slightly widened at the end and perforated by two holes through which a wire passes to form the loop.   Instead of fastening the free ends of the wire to a crossbar, they are wound in opposite

Fig. 75.
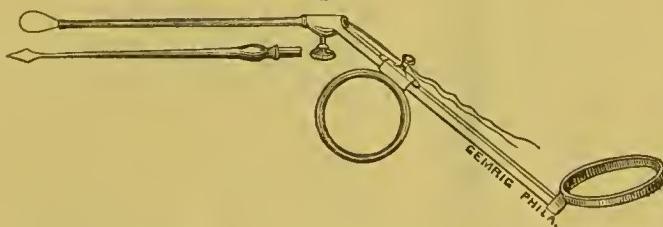
BLAKE'S WILDE'S SNARE, WITH ADJUSTABLE PARACENTESIS NEEDLE.

directions around a button on top of a short square canule 1 cm. long, which is made to slide smoothly on the square portion of the shaft.   To the under surface of the canule there is attached a ring in the plane of the long axis of the instru-

ment, by which traction is made and the loop narrowed. The handle or thumb-piece of the instrument is formed of a ring placed at an angle of 45°, transversely to the shaft.

The aforesaid barrel is made to fit into a socket at the angle of the instrument and held in place by a set-screw. Dr. Blake has also planned a paracentesis-needle to go with this instrument, and which is made to fit into the socket at the angle where it is held in place by means of the set-screw. The whole affords an admirable improvement on the original Wilde's snare.

Before the snare or any other means is employed for the removal of a polypus, the latter should be carefully examined by a curved probe, in order to determine if possible the point of attachment of the base or pedicle of the growth. I have gained great aid in this search by means of a very simple instrument, consisting of a platinum wire ring 4 mm. in diameter, soldered very neatly to a cotton-holder. This is as large a ring as will prove useful; smaller ones may be used with advantage. By passing this instrument down the well-lighted meatus, the polyp may be very much more easily and thoroughly moved about on its attachment by means of this ring-end than if the growth were touched by a smooth and blunt probe. By observing on which side the ring glides most easily, or where it meets with a resistance, a fair, if not a positive idea of the point of attachment of the polypus may be obtained. This instrument is also an excellent means of scraping off the slough from a cauterized pedicle.

Fig. 76. Fig. 77.

SILVER PROBE FOR MANIPULATION OF POLYPI.

PERMANENT PLATINUM WIRE LOOP ON FLEXIBLE SHAFT.

The Use of the Snare.—With the canal well lighted by means of the forehead-mirror, let the snare be passed over the polyp and brought as near the point of attachment as possible. There is no sensibility in the growth, but the walls of the canal which must be touched in this manipulation are extremely sensitive, and unless great skill be used, the patient will suffer pain. As a rule, the snare should be used without an ear-funnel or speculum in the external meatus. When the snare has disappeared over the polyp, let gentle constriction and traction be made, and then, if the instrument has been well adjusted, the growth, or the major portion of it, will be removed. Some hemorrhage will usually ensue, and all further operative endeavor should be postponed until a clear view of the external canal and the fundus can be obtained. Itard[1] observed a rapid hemorrhage of four ounces of blood after the removal of a polyp from each ear, and Moos[2] records an "alarming hemorrhage from the ear after the extraction of a small polypus from the short process of the malleus, necessitating a tampon." But these are rare occurrences, and are not to be cited to deter from the removal of an aural polyp as soon as it is discovered.

Polypus Scissors.—When the aural polyp is very large and tough, and projects from the mouth of the canal, I have found that, even after the wire of the snare is well adjusted, it breaks before it will cut through. In such cases I have seized the

Fig. 78.
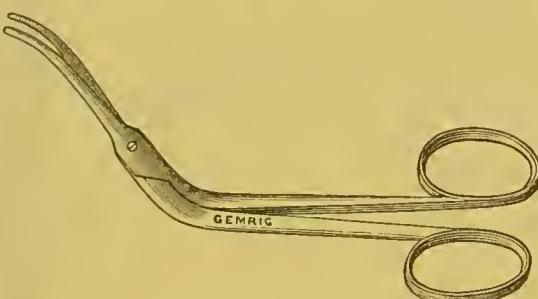
POLYPUS SCISSORS.

polyp with a pair of curved dressing forceps and, drawing it as far out as possible, have cut off as much as I was able by means of slender, strong, slightly curved, blunt-pointed scissors. The remnant may be removed by means of caustics and the wire-snare.

[1] Maladies de l'Oreille, tome ii. p. 124, 1821.
[2] Arch. of Oph. and Otol., vol. iii. p. 107, 1873.

Polypus Hook.—When polypi are quite small, not more than half the diameter of the auditory canal, I have found it very convenient to use a small steel hook, which I have caused to be

Fig. 79.
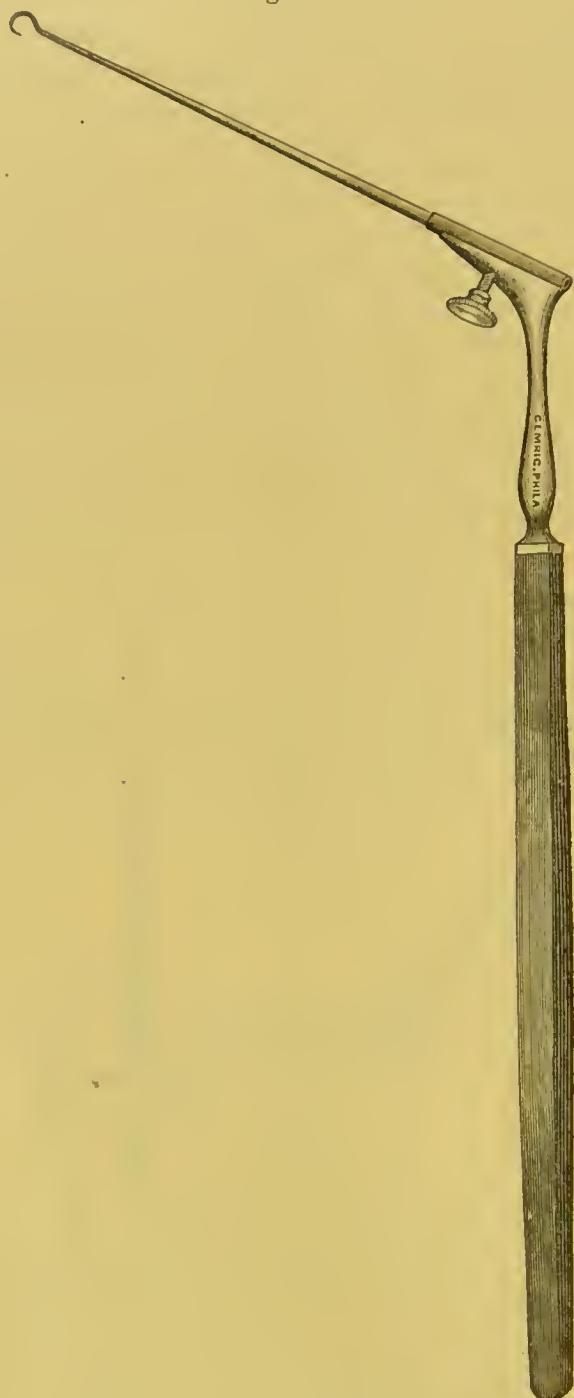
POLYPUS HOOK.

fitted to a tenotome holder (Gruber's or J. O. Green's).   By this
means, which is quite simple and attended with less darkening
of the canal than the use of the more cumbrous wire-snare, a
small polypus can be lifted from its stem without touching the
wall of the canal, and, consequently, without any pain to the
patient.

The Lever-ring Forceps of Toynbee.—Wilde's snare cannot
always be easily adjusted about the polyp if the latter is small;
and, in that case, either the hook just described, or Mr. Toynbee's

Fig. 80.

TOYNBEE'S "LEVER-RING" FORCEPS.

lever-ring forceps may be used.   But this instrument has the
great disadvantage of being complicated, expensive, and easily
broken or put out of order.   In addition to these objections, it
is straight, and in its employment the hand of the operator
interferes with his vision.   But, if a small, slightly attached
polypus be caught by the rings of the instrument, the growth
may be very easily removed by it.   If a polypus extends to the
meatus externus and can be easily reached, it may be seized

Fig. 81.
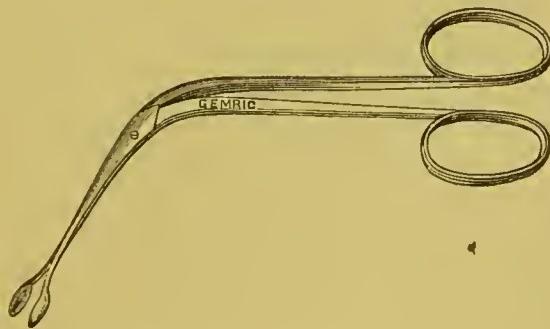
FORCEPS FOR REMOVAL OF A POLYPUS OR A FOREIGN BODY SITUATE NEAR THE MOUTH OF THE
EXTERNAL AUDITORY CANAL.

with a small but strong instrument, shown in Fig. 81.   But
this instrument should never be used in a narrow meatus, nor
should an attempt be made to seize with it a polypus situate
far down the external auditory canal.

Dr. Jacoby,[1] of Breslau, has applied the galvano-caustic method to the removal and treatment of granulations and polypi in the ear, with asserted success. But it is a means no surer nor more rapid than the more usual and less complicated methods just detailed, and certainly no less, but perhaps more, painful.

Mr. Toynbee proposed to destroy polypi by applying to them potassa cum calce, an unmanageable, slow, and dangerous procedure, and one not at all in practice now-a-days. In the latter part of his career, Mr. Toynbee succeeded in destroying polypi by gentle and continued pressure by means of small pieces of sponge or wool.[2]

Dr. Edward H. Clarke[3] has succeeded in causing aural polypi to disappear by injecting into their structure, by means of a hypodermic syringe, a few drops of the solution of perchloride of iron, or of persulphate of iron.

Treatment after removal of the Aural Polyp.—A number of suggestions have been made respecting the applications to be made to the diseased ear after the polyp is removed by evulsion. Both the matter and the mode of its application are deserving of the greatest consideration. The best applications are, nitrate of silver, monochloro-acetic acid, and chromic acid, all of which are to be used in concentrated solution.

Nitrate of silver in the solid state may be applied by means of a porte-caustique, as recommended by Wilde. But he enjoined the greatest care in getting to the seat of the polypus, and only there, lest the auditory canal be cauterized and inflamed. But at best the "solid stick" is a dangerous application about the ear, and should, therefore, be kept out. A saturated, aqueous solution of nitrate of silver (480 gr. to f℥j) may be advantageously applied to the seat of the polypus and any surrounding granular surface, by means of a tuft of cotton on the cotton-holder. This will cause no pain so long as it is not brought in contact with the skin of the auditory canal. The remnant of the polyp and the more or less granular mucous tissues in the drum-cavity are not sensitive to it. But, even the saturated

[1] Archiv f. Ohrenh., Bd. v. p. 1, and Bd. vi. p. 235.
[2] See "Diseases of the Ear;" supplement by Mr. Hinton, p. 433.
[3] Observations on the Nature and Treatment of Polypus of the Ear, Boston, 1867, p. 71.

solution of nitrate of silver may act too slowly, on account of
the superficial slough which it forms.

Chloro-acetic acid,[1] as suggested by Mr. Dalby,[2] is much
stronger, and therefore better. Its application should be made
like that of nitrate of silver in solution, viz., by means of a tuft
of cotton on the cotton-holder; or it may be applied, as sug-
gested by Mr. Dalby, by means of a camel's hair brush. *It
should never be instilled into the meatus.* Its application at best
will cause some burning, which is, however, invariably quelled
by a syringing with warm water. In order not to get too much
into the ear, it has been my plan to wrap the point of the cotton-
holder with a small, firm tuft of cotton, which projects about
two mm. beyond the point of the holder and is about two mm.
thick. This free end of the tuft is soaked with the acid and
then applied to the diseased spot—nowhere else—under the best
illumination. This should be applied every day or two until
all signs of the root of the polyp have disappeared. No positive
length of time can be assigned over which such treatment may
extend, but it must be kept up until every vestige of the growth
is removed, or the pain and annoyance of the patient will have
been endured for nothing. The caustic may be alternated with
strong solutions of sulphate of zinc (5, 10, or 20 gr. to f℥j water),
or with the undiluted liquor plumbi, as suggested by Hinton
and others.

Chromic acid, an escharotic still more powerful than either of
the two preceding ones, may be used with great and rapid aid
in removing granulations, or the remnants of a polypus, as has
been shown by Dr. W. W. Seely,[3] of Cincinnati. I have em-
ployed this for the destruction of the broad attachment of the
large mucous, and fibroid polypi, but not very often for the
destruction of smaller polypoid growths or their attachments.
Its application may cause pain, which comes on an hour or more
after the root of the polypus is touched, and continues as a dull
aching for some time. This gradually wears off, if the acid has
not been applied too freely, and every possible precaution must
be observed to avoid this, and when the patient is next seen it

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[1] I have always used that made by Merek, of Darmstadt.
[2] Diseases and Injuries of the Ear, p. 160, Philadelphia, 1873.
[3] Tr. Amer. Otol. Soc., vol. i. p. 166, 1871.

will be found that a large eschar has formed at the points touched by the acid. Under no other application does the remnant of the pedicle of a polypus disappear so surely and so rapidly. It should be applied in the same manner as the solution of silver or the chloro-acetic acid. A few crystals should be crushed and slightly moistened with water, and, into this concentrated mixture, the tuft prepared as described above, when alluding to chloro-acetic acid, should be dipped and then conveyed to the diseased spot. The latter may be gently brushed or pressed upon by the tuft of cotton thus prepared. The cotton tuft must not contain much acid, nor should that which it carries be too fluid—it should be pasty—for otherwise when the cotton is pressed on the granulation, or the cut surface of a pedicle, an excess of acid would be squeezed out, and run upon the healthy tissues. But care will prevent any such mishap, and enable any one to command the rapid and thoroughly curative action of chromic acid.

The consideration of the results named under the fourth head (p. 491) will be reserved for the following chapter.

CHAPTER VIII.

COURSE AND CONSEQUENCES OF CHRONIC PURULENT INFLAMMATION—Continued.

CHRONIC suppuration of the tympanum, after a longer or a shorter duration, may extend inward toward the labyrinth and the auditory nerve, upward through the tegmen tympani, directly toward the middle lobe of the brain, backward through the mastoid antrum to the mastoid portion, its cells, and the lateral sinus, or outward to the bony auditory canal.

The close anatomical relation between the tympanic cavity and the above-named regions, has already been pointed out when considering the anatomy of the middle ear. But it will be necessary to recall that relation at this time in order to obtain a just idea of the mode and extent of the ravages made by chronic suppuration in the various parts of the temporal bone, and even in the bones adjoining it.

Chronic suppuration of the middle ear advances by the successive stages of ulceration of the mucous membrane, periostitis, ostitis, caries, and necrosis of subjacent bones. The interval between the acute stage and these successive chronic stages, varies greatly in length. In some instances the acute stage is rapidly succeeded by all the others, even the necrotic exfoliation of some of the most important parts of the internal ear, while in others, a generation, or an ordinary lifetime, may elapse before the chronic process in the mucous membrane seems to leap at a bound to caries and necrosis of the bone beneath. And this is true, whether the advance of the tympanic disease is inward, backward, upward, or outward.

The least common result of such a process is necrosis and exfoliation of the cochlea, either alone or in conjunction with the rest, or parts of the labyrinth, and other portions of the temporal bone.

After a chronic suppuration has been in process for a period varying from a year or two to thirty or forty years, during which time the patient has suffered from nothing but the discharge, quite suddenly a new train of symptoms is presented. These consist chiefly in an attack of severe pain in the ear, without any apparent cause so far as the patient can assign, swelling about the auricle, and bulging of the latter from the side of the head, chill, fever, constipation, intense vertigo, nausea, vomiting, and a peculiarly distressing and intense tinnitus in the affected ear. The hardness of hearing is increased to total deafness. To these symptoms may be added those consisting of paralysis of the facial muscles, and of the extremities on the side corresponding to the diseased ear, delirium, coma, and death. Though not infrequently, after the paralysis of the face and the extremities has been fully established, it, with the pain, tinnitus, nausea, vertigo, and vomiting, is quite suddenly relieved by a copious discharge of pus from the ear. The patient then recovers; with, however, the absolute deafness, characteristic of destruction of the labyrinth, and with some discharge from the ear. Upon examining the external ear in such cases, not only bare bone may be felt, but loose sequestra are found at, or near the external auditory canal, or protruding from the opening of a sinus behind the auricle. In those cases in which the cochlea has been thrown off as a separate sequestrum, it has been found in the auditory

canal, from which it has been lifted with ease. When joined to other bony tissues, forming a large sequestrum, the whole has been worked from the meatus, or from the aforesaid opening behind the auricle.

Exfoliation of the Cochlea.—Exfoliation of the cochlea, as a sequestrum separate from the rest of the labyrinth, has been observed and described by Ménière,[1] Gruber,[2] Hinton,[3] Toynbee,[4] Cassells,[5] Parreidt,[6] Boeck,[7] and Dennert[8] and Lucæ.[9]

In the vast majority of these cases the cochlea was taken out, or came out during life, the patient, of course, remaining totally deaf in the affected ear, but free from facial paralysis. Only in two cases, that of Boeck, and in one of the three of Ménière, was the necrosed cochlea found after death as a free sequestrum in the external ear. The case of Boeck was further exceptionally characterized by facial paralysis. The patient, a child under two years of age, succumbed during the progress of the necrotic disease of the internal ear, from acute hydrocephalus. In all of these cases the cochlea was removed through the external auditory meatus; not uncommonly, before the acute symptoms of the detachment of the sequestrum, the external ear and mastoid portion were free from pain or tenderness on pressure, a very marked, though not an invariable diagnostic difference between deep-seated inflammation of the labyrinth and mastoid disease. Sometimes pieces of the bony auditory canal precede the exfoliation of the cochlea.

The case observed by Dr. Cassells in which the cochlea was thrown off, and removed finally by him from a perforation in the membrana tympani, from which it was projecting, was said not only to have retained the hearing on that side, but to have shown an improvement in hearing after the operation. But, not to suppose that there was an error of observation respecting the hearing in this case, is to assent to a rejection of the theory

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[1] Gazette Méd. de Paris, No. 50, 1857.
[2] Wiener Allg. Med. Zeitung, 1864 ; also "Lehrbuch," p. 542, 1870.
[3] See Toynbee, Archiv f. Ohrenh., Bd. i. p. 114, 1864.   [4] Ibid.
[5] "Questions of Aural Surgery," by James Hinton, London, 1874, p. 296.
[6] See Schwartze, Archiv f. Ohrenh., Bd. ix. p. 238, 1875.   [7] Ibid.
[8] Archiv f. Ohrenh., Bd. x. p. 231, 1876.
[9] Archiv f. Ohrenh., Bd. x. p. 236, 1876.

of audition as it stands to-day. There must have been an *incomplete isolation* of the good ear during the test of the power of the diseased side.

Facial paralysis is rarely observed, and never permanent, when the cochlea alone is thrown off. From recorded accounts it appears that only Toynbee has observed this symptom in connection with exfoliation, during life, of the separate cochlea. Necrosis and exfoliation of both cochleæ have been observed only by Gruber.[1] The patient, a lad twelve years old, who had suffered from otorrhœa for several years after scarlatina, showed no signs of facial paralysis, but remained totally deaf.

Exfoliation of the Cochlea, Vestibule, Semicircular Canals, and Deeper Parts.—Larger sequestra, composed of not only the cochlea, but the rest of the labyrinth, the porus acusticus internus, and even the major portion of the temporal bone, have been removed during life and described, by Wilde,[2] Shaw,[3] Toynbee,[4] C. R. Agnew,[5] Voltolini,[6] and O. D. Pomeroy.[7]

In the two cases of Toynbee the sequestra were not removed until after death, which occurred in consequence of the severe and previously neglected aural disease. In the other cases the large sequestra were removed through the external meatus, excepting in the case under the care of Dr. Pomeroy, in which the sequestrum, the major part of the temporal bone, came out by a natural process from the opening of a sinus behind the auricle. The implication in the necrosis of so much of the temporal bone as ensues when the entire labyrinth, the porus acusticus internus, and other parts of the petrous bone are thus thrown off as sequestra, is naturally attended with facial paralysis as a *markedly characteristic* symptom, besides the intense deafness.

[1] Wiener Allg. Med. Zeitung, 1864.

[2] Treatise on Diseases of the Ear, Phila., 1853, p. 358. Sir Philip Crampton's case.

[3] Seventh Vol. Trans. Path. Soc., London. See Toynbee, Archiv f. Ohrenh., Bd. i., 1864.

[4] Two cases: Archiv f. Ohrenh., Bd. i. 1864.

[5] Amer Med. Times, vol. vi. p. 183 ; also V. Troeltsch on the Ear, 2d Am. ed. p. 471, 1869.

[6] Monatsschr. f. Ohrenh., 1870, No. 6.

[7] Trans. Am. Otol. Soc., 1872.

Besides the invariably ensuing facial paralysis, which may be permanent, there has occurred, as in the case reported by Wilde, temporary paralysis of the arm and leg on the side of the diseased ear. The latter paralysis, however, vanishes upon the cessation of the acute symptoms, and may be considered as due to pressure from the retained pus in the ear. All the symptoms observed in connection with necrosis and exfoliation of the cochlea, are intensified when the necrosis involves other parts of the labyrinth and the neighboring petrous bone.

Not only are the deep-seated pains, tinnitus aurium, deafness, vertigo, nausea, and vomiting urgent symptoms, but the external ear is tumefied and more sensitive to pressure ; the mastoid portion is more apt to become tender and painful ; an abscess may form there, and opening, leave a sinus which leads to dead bone ; the discharge is excessively fetid ; the cerebral symptoms often threatening ; convulsions and coma have supervened, and death has occurred, as shown in two cases recorded by Toynbee. In one of these an opening was found leading from the sequestrum in the posterior part of the petrous bone to the jugular fossa. In necrosis originating in the inner wall of the tympanum, there seems to be a tendency on the part of the disease to enucleate the hard and resistant labyrinth from the surrounding more porous part of the petrous bone in which it lies imbedded.

Treatment.—It is usually found that up to the time the patient applies for relief from the acute and painful symptoms which have been suddenly added to the chronic aural disease, there has been almost total neglect of the ear, and that the external auditory canal is blocked by one or more polypi, which has caused a retention and consequent burrowing of pus. It therefore becomes necessary, as the first step in the treatment, to free the external auditory canal and permit the escape of the products of inflammation ; after which, if dead bone be recognized, the escape of the sequestra should be favored, either by hygienic or direct surgical means. It not uncommonly happens that, before the sequestra of the deeper parts are removed, pieces of the more superficial parts of the external auditory canal escape or have to be pulled either from the meatus or a sinus near the auricle. If such an opening behind the ear leads to dead bone, a poultice kept constantly over the mouth of the sinus—*not over the auditory*

meatus—will be found to greatly favor the process of nature in throwing off the sequestra. Traction upon the latter should *never* be made until they are entirely loose. Then, the sooner they are removed the better for the ear and the life of the patient.

Polypi and polypoid granulations are no sign of dead bone, yet the presence of carious bone in the ear is always attended by the growth of granulations. These are very apt to be seated near the inner opening of a sinus, and are not uncommonly found attached to the auditory canal, thus forming an exception to the general rule in respect to the point of attachment of such growths. They are, in fact, to be regarded as exuberant granulations rather than polypi. They should be extracted as stated, but they will almost surely recur until the dead bone is removed. Then they will be found to disappear in the general improvement which takes place in the ear. So long as they do not interfere with the thorough cleansing of the ear, while the dead bone is still present, their presence need not be combated, beyond keeping them down to a point which permits the escape of pus and the entrance of cleansing fluids and medications.

The general constitutional treatment should be of the most supporting kind: good food, meat, milk, and eggs; iron, quinia, and cod-liver oil. In the more virulent cases, resembling in many respects a typhoid condition, spirits may be given if the failure in strength of the patient indicates such administration.

A result of neglected purulent inflammation of the tympanum, more common than caries of the cochlea and labyrinth, is inflammation, caries, and necrosis of the mastoid cells and of the entire mastoid portion of the temporal bone. Not only is this a common event, but it is also a very fatal one. But this fact is not a new one to otologists; more or less distinct records of this disease can be found throughout the history of medicine and surgery. A greater want is felt in the paucity of accounts of how to prevent it; or, if it is fully established, how to recognize and cure it. It is much easier to prevent chronic purulent inflammation of the tympanum from passing into mastoid disease, than it is to cure the latter when carious processes in the mastoid have once begun. Yet, even the prevention admits of no slighting; no part of the body tolerates neglect or improper treatment so poorly as the middle ear, when attacked by chronic

suppuration. Caries of the mastoid is rarely a necessary result of the latter disease ; it is almost invariably traceable to neglect of the purulent tympanic disorder.

It must be remembered that the mastoid portion of the temporal bone is covered by periosteum, a continuation of that of the external auditory canal, and that its cavity consists of intercommunicating air-cells lined with mucous membrane. These cells, moreover, may extend over the upper wall of the external auditory canal, upward toward the parietal bone and inward toward the petrous part of the temporal bone ; in some instances, however, even in the adult the mastoid portion is small, and its cells rudimentary.

In the normal bone, veins pass from the upper part of the mastoid cavity to the lateral, or to the superior petrosal sinus. This highly important cavity has but one outlet, viz.: by means of the mastoid antrum into the tympanum. But this outlet is both small, and, so far as drainage is concerned, badly placed, since it is at the top of the cavity. Only the siphon action could empty the lower cells at the tip of the process, and it is probable that sometimes the cells are thus naturally drained when the discharge is excessive.

It seems probable that the mastoid portion and its cells resist for a long time, in some cases, the chronic ulceration in the tympanum, for in very chronic cases the remnants of the cells, or the shell of the mastoid cavity, are found choked with a cheesy mass, consisting of epithelial débris, pus, etc., forming a so called cholesteatomatous mass. This at last, choking up every avenue of escape for the products of inflammation, becomes a distending, irritating, and poisonous mass, which if not removed will either induce purulent absorption, or an irruption into the lateral sinus, or both of these events.

Mastoid Disease; Symptoms and Course.—For clinical convenience mastoid inflammation consecutive to purulent disease in the tympanum, may be divided into:—

1. Periostitis of its outer surface.

2. Congestion and inflammation of the mucous membrane lining the air-cells of the mastoid cavity.

3. Caries and necrosis; followed by meningitis, thrombus in the lateral and other sinuses of the brain, embolism, pyæmia, and cerebral abscess.

1. The *first* is not uncommonly observed as an attendant of acute inflammation of the middle ear, with consecutive inflammation in the external auditory canal. It may also appear during chronic suppuration in the tympanum. An abscess may form over the mastoid as a result of this periostitis, and, in some broken-down and scrofulous diatheses, caries of the outer table may be thus induced. The latter, *asthenic* form is characterized by its painlessness; the former, the *sthenic* type, by the reverse. The asthenic process may occur as a sequel of diphtheria in children, as shown by the following cases:—

CASE I. Frank H., 16 months old, born in Philadelphia, was attacked by diphtheria in March, 1875, and was treated for that disease by Dr. L. D. Harlow, who finally sent him to me for treatment of the aural disease, six weeks after the onset of the diphtheria. The mother of the child states that, on the fourth day after the initial symptoms of diphtheria, she noticed a red swelling behind the right auricle over the mastoid. This swelling increased rapidly in size, but is said to have caused the child *no* pain, nor was it markedly tender on pressure. There is no history of any previous aural disease, nor of any diphtheritic deposit in or about the external ear.

By Dr. Harlow's advice, the mastoid abscess was poulticed, and in a few days it was opened by him, with a free discharge of pus. From that time until I saw the patient it seems that a constant and offensive discharge continued from the mastoid incision and from the ear.

I examined the case for the first time on the 22d of April, 1875, about six weeks after the onset of the diphtheritic disease, and found by the probe, dead but adherent bone on the mastoid portion near the external auditory canal. The auditory passage was blocked by granulations. There was also considerable swelling about the ear, and the pus tended to burrow in the direction of the sterno-cleido-mastoid muscle. There was a sinus running from the mastoid abscess into the external auditory canal, which will, I think, account for the discharge from the ear and the granulations alluded to above, as well as lend probability to the statement of the mother, that the mastoid disease preceded any kind of discharge from the external auditory canal. On the 27th of April, 1875, I made an incision, an inch long, over the mastoid portion, which gave free exit to the

pus, and diminished the discharge from the ear, as well as the tendency on the part of the pus to burrow downward into the neck. Through this incision I could feel, with my little finger, the denuded bone.

In a month, on the 28th of May, there was a detached piece of bone at the opening I had made over the mastoid, and, on June 1, I extracted the sequestrum represented in the wood-cuts. The general swelling around the ear had gone down. The local treatment up to this time had been simple cleansing of the ear and keeping the mastoid incision free enough for drainage, and to permit the escape of dead bone.

Fig. 82.

Fig. 83.

OUTER SURFACE. (Natural size.)

INNER SURFACE. (Natural size.)

The child was considerably run down by his blood-disease, but, with tonics and the good effects of a summer in the country, rapidly grew better. The ear was kept carefully cleansed, as was the opening of the sinus behind the auricle, and a weak solution of sulphate of copper (3 gr. to f$\bar{3}$j) was used for instillation and injection.

In two hundred and ninety-five days after the free incision over the mastoid, the sinus behind the auricle finally closed; a slight discharge, a few drops, still came from the external ear every day or two.

So far as could be ascertained in so young a patient, then about twenty-six months old, there was no impairment of hearing left as the result of the mastoid disease.

In this child some of the chain of glands situated over the mastoid portion of the temporal bone and along the tract of the sterno-cleido-mastoid muscle, have successively enlarged and sluggishly suppurated, without pain, which would seem to indicate that the inflammation over the mastoid portion, and of its outer table, in this case was due to an inflammation of such a gland, the first in the chain to be diseased by the diph-

theritic poison. Such a disease as this, occurring *over the outer wall* of the mastoid portion *in a child*, becomes of moment not only to the hearing, but even to the life of the patient. The latter is due to the fact that *in children* there is much greater probability of an extension inward of such a disease as I have just described, than there is of its successful outward termination, for the dense tissues over the mastoid in young children are much more resistant than is the thin and somewhat cribriform or dehiscent outer table of the mastoid portion of the temporal bone. Hence, in just such a sluggish form of abscess over the mastoid as was found in this child, there may be danger of a burrowing inward of the disease, deep inflammation of the mastoid cells, caries extending into the cranial cavity, pyæmia, and death.

It may be asked, did this disease arise inside or outside of the mastoid portion of the temporal bone? It would seem from the latter, because the first aural symptom, if it may be called such, was the mastoid swelling, unaccompanied by pain in the ear. Had the disease started in the middle ear or in the mastoid cells, there would surely have been symptoms of great suffering in the child at the outset, and subsequently, it is highly probable, we should have found an impairment of hearing; whereas that function has not appeared to be affected at any time during the disease.

The following case is one resulting from scarlatina and diphtheria combined; but in it, too, I am inclined to regard the carious erosion as starting on the outer side of the mastoid:—

CASE II. Mary Coogan was attacked in April, 1876, when three and a half years old, with diphtheria and scarlatina. The throat symptoms were very bad.

In about three weeks after the beginning of the fever, which was soon followed by a running from the right ear without pain, facial paralysis was observed on the right side, and in three weeks an abscess formed over the mastoid and spontaneously opened. There was no pain at any time. The facial paralysis now began to disappear, and was only very slightly visible in October, 1876, when I first saw her; in a few weeks it vanished entirely. The external auditory canal was blocked with granulations springing from the posterior wall; there was a large sinus close to and behind the auricle leading to the external auditory

canal; offensive pus was discharged from the meatus and the
sinus; denuded bone was felt with the probe passed into the
sinus and external auditory meatus. The child was given cod-
liver oil and some other tonics; a poultice was kept constantly
over the opening of the sinus *behind* the auricle; and by Decem-
ber, 1876, a sequestrum could be distinguished, one end of which
began to protrude by January, 1877, from the sinus. The
sequestrum appeared to consist of the major part of the outer
wall of the mastoid and that part of the latter which goes to
form the posterior wall of the bony auditory canal. And this
was verified by the extraction of the sequestrum through the
sinus on February 12, 1877.

This was done with the aid of Drs H. Allen and W. H. Baker,
by making the opening of the sinus wider, and then by pulling
on the entirely detached piece of bone. There was little or no
hemorrhage, no vessel of importance having been interfered with.

As shown in the accompanying wood-cuts, the sequestrum con-
sisted of a large number of the air-cells of the mastoid cavity as
well as of a large part of its anterior and outer wall.

Fig. 84.   Fig. 85.
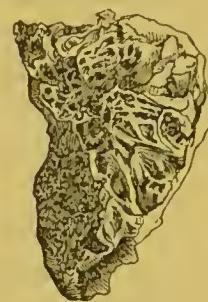
OUTER SURFACE. (Natural size.)   INNER SURFACE. (Natural size.)

The ear was syringed with warm water for a few days; the dis-
charge from the ear ceased entirely; the granulations shrivelled
and disappeared; the opening behind the auricle closed.

The *sthenic* variety of mastoid periostitis is characterized by
pain and tenderness in the mastoid portion, with some redness
of the skin. It may mislead the observer into the idea that it
is inflammation of the mastoid cells. But the less deep-seated
pain in the ear and head, and the readiness with which the
periostitis yields to leeching or a deep incision (Wilde), will
serve as diagnostic points.

It must be borne in mind, however, that inflammation of the external periosteum may be associated with deeper inflammation in the mastoid cavity.

2. *Congestion and Inflammation of the Mucous Membrane of the Mastoid Cells.*—A simple congestion of the mastoid cells may coexist with a tympanic inflammation. The pain may not be referred to the mastoid in all cases, though usually the pain is thus referred, and there is noted some swelling over the mastoid. This congestive process may readily yield to treatment or even undergo resolution. If not, there may ensue a deposition of a reddish, pulpy material, as shown by A. H. Buck,[1] followed by suppuration, caries, and necrosis in and about the mastoid cavity.

In some instances after the congestive stage has been fully established, instead of an active inflammation, there ensues a subacute process in the mastoid cells, analogous to the chronic catarrh supervening upon a severe congestion of the middle ear. It was noted, when alluding to inflammatory processes in the middle ear, that although a congestion in some instances was followed by destructive suppuration, in others it was succeeded by the more conservative and sclerotic process known as chronic catarrhal thickening or proliferation.

An analogous process may succeed the congestive stage in an inflammatory process in the mastoid cavity, and lead to thickening of the mucous membrane covering the bony septa between the mastoid cells, and to an hyperostosis of the latter. That such a slow and insidious process may occur in the middle ear and mastoid cavity seems probable from the cheesy accumulations almost invariably found in the worst cases of necrosis of the mastoid cells and temporal bone.

3. *Carious Inflammation of the Mastoid Cells.*—Leaving out of consideration those extraordinary cases of acute inflammation of the mastoid cells, in a previously entirely healthy ear, it may be stated that after a purulent inflammation has existed for a longer or shorter time in the middle ear, an acute and virulent inflammatory process seems to be superadded to the chronic process already fastened on the organ of hearing. This acute stage in the disease already existing in the mucous membrane of the middle ear and mastoid cells, is analogous to a similar

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[1] Archives of Oph. and Otol., vol. iii., 1873.

process in a diseased mucous membrane anywhere else in the body. Hence an early symptom of the acute engorgement of the vessels in the mucous lining of the ear, is a diminution or an entire cessation of the discharge which may have been existing for a long time. And just because fatal cases have been, for the above reasons, preceded by a cessation of discharge, there may have arisen the prejudice against stopping an aural discharge. But the same argument might be used against stopping a chronic discharge from the bowels or the lungs.

After an unusual exposure to cold, after a blow on the diseased ear, or in the natural course of the purulent tympanic disease, severe and increasing pain is felt in the organ, which bids defiance to all ordinary remedies for relief; or, if a temporary relief be experienced by fomentations, leeching, and opium, the pain returns very quickly, and perhaps with greater intensity.

The discharge, which, as stated, had at first ceased, may be renewed, though altered in appearance and usually offensive in odor. The mastoid region becomes very sensitive to pressure, the skin over it becomes slightly boggy and reddened, the deep-seated pain in the ear is found to be shooting forward toward the brow, and upward to the vertex, and backward toward the occiput, and the auricle may, during the more acute paroxysms of pain, stand out farther from the head than its fellow; but this symptom may disappear in a few hours, to be observed when another paroxysm of pain comes on. This variability in the position of the auricle, is a marked diagnostic symptom of mastoid affections, and should obtain earnest attention from the surgeon. In some instances it is very striking, and, as after abstraction of blood it subsides, it may be due to the intense engorgement of the dense tissues about the ear. It surely is not due to the formation of pus, for it appears too soon in the disease. It may be analogous to the swellings lower down in the neck, in the sterno-cleido-mastoid muscle, which have been observed by some (Voltolini and others) as an accompaniment of mastoid periostitis. These swellings, though large, red, tender, and painful, usually disappear without suppuration. The tendency of mastoid pain to exacerbations, chiefly at night, is worthy of note. As the mastoid symptoms increase in severity, the general appearance and condition of the patient are most striking and pitiable. Not uncommonly the sufferer con-

tinues to go about his daily duties, especially when unaware of
the true nature of his disease. The pain deep in the ear and
head is most intense, the pulse, often slow and weak at first, be-
comes very rapid, sleep is out of the question, the appetite fails,
nausea and vomiting ensue, the tongue becomes dry and rough,
and the face becomes peculiarly haggard and bathed in cold
sweat. Though very weak, the patient may still continue to
walk about, not unfrequently coming regularly to his physician.
But, gradually, unless relief is obtained by evacuation of the
products of inflammation which have accumulated in the mas-
toid, it is observed that the answers of the patient are becoming
incorrect respecting even his name and place of residence, that
his intellect is confused, and his strength is failing. Rigors
and irregular fever set in, every movement of the body now
causes almost indescribable agony in the head; stupor and coma,
with alteration in the size of the pupil on the affected side of
the head, are noted in rapid succession, and, unless speedy relief
comes, death supervenes.

This train of symptoms is not obscure, but points most posi-
tively to the true nature of the terrible disease of which it
might be said to be eminently characteristic. And yet a true
diagnosis is rarely made until too late, the disease being vaguely
called cerebral. But in most cases its cerebral character is in
no way a necessary one, and would either never show itself, or
be obliterated entirely, if prompt and proper treatment were
applied to the disease while confined to the mastoid. As it is
easier for pus to find its way through the inner wall of the
mastoid cavity and transverse sinus than it is to force its way
through the outer mastoid table, it is not likely to choose the
latter way; and hence the direful accidents following pent-up
pus in the mastoid cells. And yet men have been allowed to
die with no better effort for their rescue than a poultice bound
over the bony cavity in which lay the cause of their dissolution.

The best that nature can do in inflammation within the mas-
toid cavity, is to break down by necrosis the outer mastoid table,
or to force the pus through a natural dehiscence which might
happen to exist in a given case. And in some instances, it
would seem that nature thus gave release to the products of
inflammation in the mastoid cells. But, in the vast majority
of cases, such relief cannot be reasonably hoped for, and the

natural result then is an erosion of the thin wall of the lateral
sinus, or a passage of the inflammatory process to the meninges
and the sinuses of the brain, by the vascular communication
existing between the mastoid cavity and the former structures.
Thrombi may entirely fill the lateral sinus on the side of the
affected ear and extend into the corresponding petrosal sinus.
These may undergo suppuration and gangrene, and give rise to
embolism and blood-poisoning. A deep-seated abscess not un-
frequently forms in the muscles of the neck near the affected
mastoid cavity.

Cerebral abscess is not an uncommon result of mastoid disease,
as well as of chronic purulent disease in the tympanum. Its
origin from purulent absorption would seem to be rendered all
the more positive from the fact observed by Von Troeltsch, that
it may occur in the brain on the side opposite to the diseased
ear. The tympanic cavity, though the starting-point of these
ravages, may be found in a measure intact, as though the force
of the chronic suppuration had been spent on the mastoid and
its vicinity. Hence, even in fatal cases of mastoid disease, the
ossicles are sometimes found in situ, and the membrana tym-
pani only perforated but not destroyed. In very rare instances,
mastoid disease may run its full course without an accompany-
ing perforation in the drum-head.

Treatment of Mastoid Disease.—Inflammation of the perios-
teum will usually yield to the local abstraction of blood, which
is best accomplished by thorough leeching, or by a deep inci-
sion down to the bone. The latter procedure, Wilde's incision,
will not only relieve by depletion of the congested vessels, but
will also have the happiest results in relieving the tension of
the dense tissues over the mastoid. Without doubt such an
incision, besides giving immediate relief to the patient's pain,
in many instances cuts short a process which might extend to
deeper parts and produce caries of the mastoid portion. This
incision should be made about one-fourth of an inch behind the
attachment of the auricle, and extend for about an inch, or even
an inch and a half, across the mastoid in the line of the course of
the st rno-cleido-mastoid muscle. Sometimes a branch of the
posterior auricular artery is severed in this operation, but the
hemorrhage is of service rather than otherwise. It is to be
controlled on general surgical principles. A poultice may be

applied to the incision, and the latter kept open, if necessary, by means of a tent. The bone beneath the thus incised periosteum may be found entirely healthy, though inflammation may be going on in the mastoid cavity. If the mastoid cells are deeply congested or inflamed, the incision of the periosteum will be but palliative, and the renewal or increase of the pain will indicate the probability of the *second* condition of mastoid disease, viz.: *Congestion and inflammation of the mucous membrane of the mastoid cells.* If, after the above-named treatment, local depletion and the incision of the periosteum over the mastoid, the pain, which may have been further combated by anodynes, should still persist, grow worse and be accompanied by symptoms of general constitutional derangement, the outer mastoid wall should be perforated.

Artificial Perforation of the Mastoid Portion of the Temporal Bone.—So far as the statements of the past concern this operation, they do not demand an extended reference here. Any reliable book on diseases of the ear yet published, will give details respecting the unchecked ravages of chronic otorrhœa truly appalling to the honest reader. It is claimed now, and with reason, that mastoid disease and its fatal results can be prevented in many, if not in most cases; or if inflammation is set up in the mastoid cells, a *safe* means of relief is afforded in the operation of perforating the outer table of the mastoid portion.

Excepting to allude briefly to a few of the prominent historical facts connected with this operation, it will not be necessary to recall the past; I shall base my statements mainly on the writings published within the last ten or twelve years by men, most of whom are yet living and working.

The history of perforation of the mastoid portion begins with the writings and operations of Jean Louis Petit,[1] and of Jasser,[2] a Prussian military surgeon. Petit died in 1750, and, as the accounts of his operations were posthumous, Jasser, who operated on the mastoid not until 1776, may have been entirely ignorant of the labors of the distinguished surgeon of France.

[1] See Schwartze and Eysell, Archiv f. Ohrenh., Bd. i., N. F., 1873; also, Saissy, op. cit., p. 164.

[2] See writings of Roosa, Buck, and others.

Although both of these men operated most successfully in their first cases, the indications for the operation were evidently not clearly comprehended by their contemporaries and immediate successors. The operation was most mistakenly resorted to for the relief of deafness, and even Jasser seems to have lost sight of the real worth of the operation, viz., the *evacuation of the products of inflammation from the mastoid portion*. As the real worth and applicability of the operation were entirely misconceived; as it was resorted to empirically, on all sides, to relieve deafness, and not to keep pus from burrowing to the brain, reports of failure and of death, consequent upon it, soon followed, and the operation was rejected without one word of justice.

No fact of history points more conclusively to the total misconception of the true intent of the operation than the fatal result of it in the case[1] of Baron von Berger, physician to the King of Denmark. Dr. Berger, having suffered for a long time with increasing deafness and noises in the ear, but without chronic suppuration, allowed himself to be thus operated on, for relief of these symptoms. The perforation of the bone was followed by injections into the cavity of the cells; fever and delirium soon set in; and, on the eleventh day, death occurred. The post-mortem revealed purulent meningitis, an almost rudimentary mastoid, and evidences that the trephine must have perforated the brain. In this instance, death must not be referred to the operation, but rather to a misconception of its application and a consequent blunder. But from this time on to the time of Rau,[2] the operation is alluded to rather as a curiosity of history than as one of the most valuable and simple operations in surgery. When it is remembered that this operation was a common, though a misapplied, one, it is marvellous that there are so few accounts of death from its practice, for it was a fashionable operation, until the death of Berger, for the relief of deafness *without chronic suppuration* of the ear. The revival of this operation and its true application must, according to Schwartze,[3] be conceded to Forget in 1849, and to Follin and Von Troeltsch in 1859; a history of this procedure

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[1] Schwartze and Eysell, loc. cit. See also Beck, Kr. des Gehörorgans, p. 60.
[2] Lehrbuch, p. 112, 1856.   [3] Archiv f. Ohrenh., Bd. i., N. F., 1873.

since then can be obtained by consulting the bibliographical list appended to this chapter.

Modes of Perforating or Trephining the Mastoid.—After the patient has been thoroughly etherized, let an incision be made about half an inch behind the auricle, beginning about on a line with the top of the auricle. In many instances the surgeon may be surprised at the thickness of the tissues at this point, and the depth to which he must cut before the bone is touched. The bleeding will usually be quite free, but this is no disadvantage. If an arterial branch shall have been severed, the hemorrhage of course would be controlled by a ligature. The wound may then be carefully sponged and the bone examined. It may be so soft as to yield readily to the pressure of a probe or of a knife-blade. The latter should not be too long, for fear of penetrating too far with it: therefore, I have preferred the kind of knife represented in Fig. 86.

Fig. 86.

STRONG KNIFE FOR INCISING SOFTENED OUTER MASTOID TABLE.

It will be observed that this knife is thick, strong, and short in the blade. It may be all that is required in many cases in which the bone is softened, and it is always a safe implement.

If, after the incision and dissection of the periosteum, the bone is found hard and resistant to pressure from a probe or the strong knife-blade, it may be opened by means of small trephines, bits, various kinds of chisels, drills, etc. The forms of instruments I prefer are those recommended by Dr. A. H. Buck, and shown in Fig. 87.

The Point to be chosen for Perforating the Mastoid Wall.—If pus be found beneath the periosteum, an opening in the mastoid may be suspected, and should be sought for with a probe. If such an opening is found, the perforator may be applied here and the existing hole made larger, as stated by Dr. Buck. If the operator may choose the point for perforating the mastoid, the instrument should be placed about a quarter of an inch behind the external auditory meatus, a little below the level of the upper wall of the canal. If the line of the zygoma and the

temporal ridge be extended posteriorly, until it intersects a
perpendicular drawn through the mastoid tip, the angle lying
between these lines on the side
towards the porus acusticus ex-
ternus will indicate the position
for the insertion of the point of
the perforator. A few turns of
the pyramidal borer, in a direc-
tion inward, forward, and slight-
ly upward, will usually be suffi-
cient to perforate the mastoid
wall, the average thickness of
which at the point indicated
is about one-fifth of an inch
(Buck). The opening thus made
may be further and definitely
enlarged by the use of a bit, as
represented in Fig. 87. Retrac-
tors, which are made of steel,
will be found of service in hold-
the edges of the incision out of
the way of the operator. They
are, of course, to be intrusted to
a careful assistant. After the
mastoid cells are thus exposed,
they may be broken up by means
of a firm probe, and the antrum

Fig. 87.
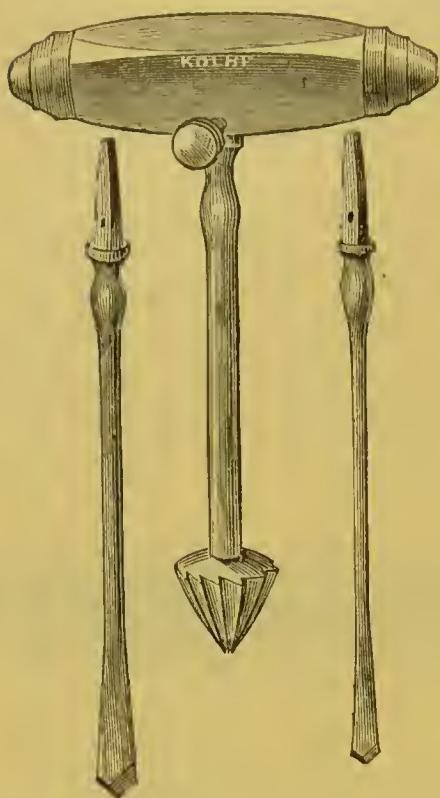
CONICAL DRILL AND BITS FOR PERFO-
RATING THE MASTOID PORTION OF THE
TEMPORAL BONE. (A. H. BUCK.)

mastoideum thus reached. Schwartze prefers the gouge to all
other implements for perforating the mastoid wall. Such an
instrument may be of value in hyperostosis of the mastoid cells
and outer wall, for, as Dr. Schwartze shows, by its employment
the cells may be bared and even the mastoid antrum reached,
by the successive removal of layers from the mastoid table.

Although the pain may have been intense and unyielding,
and the general symptoms of the patient strongly indicative of
cerebral complication, the perforation of the outer mastoid wall
may not give vent to pus, but to the reddish, pulpy matter
spoken of by A. H. Buck. The operation, however, gives the
desired relief, and, in every probability, has cut short a process
which would have rapidly advanced to suppuration, with all

the tendencies it shows to break its way towards the brain. Let the operation be but honestly regarded in the light of recent investigations, and it must be admitted that it is simple, safe, and efficient.

It becomes, therefore, the duty of every conscientious practitioner of medicine to be carefully observant of the onset of an inflammation in the mastoid cavity, and prompt to relieve it; for, by so acting, he will in all probability save life, where, in similar cases, there is every reason to know that death has occurred, simply because the true nature of the mastoid disease was not recognized, and, consequently, no rational means of relief resorted to.

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[1] In the preparation of this list the author has been most ably assisted by Dr. Washington H. Baker, of Philadelphia.

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SECTION VI.

DISEASES OF THE INTERNAL EAR.

CHAPTER I.

PRIMARY AND SECONDARY INFLAMMATION.

DISEASES of the internal ear are rare. They may be either primary or secondary in their origin, but those of the latter kind are by far the more frequent in occurrence. Primary affections of the ear may be considered under anomalies of formation, anæmia, hyperæmia, and inflammation. The latter may also be a process secondary to traumatic injuries which are productive of hemorrhages and other effusions into the labyrinth, and of concussion of the auditory nerve and its terminal filaments. It is also supposed, with more or less certainty, that structural changes may be brought about in the internal ear by the following diseases, viz., the continued fevers, the exanthemata, mumps, cerebro-spinal meningitis, syphilis, cerebral tumors, aneurism of the basilar artery, and especially by tympanic disorders.

Anomalies of Formation.—Malformations of the internal ear have been discovered in those with normal, as well as in those with abnormal hearing. These deviations from the normal standard may consist in an unnaturally large or small internal ear, or in a want of some or all of the parts of the internal ear. A want in the number of the parts of the internal ear is, however, of greater functional importance. Yet even in this respect the ear may be defective and yet not entirely deaf.[1] Rudimentary development, however, is usually found only in deaf mutes. In a case reported by Michel[2] and referred to by

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[1] Gruber, Lehrbuch, p. 613.   [2] Gazette Méd. de Strasbourg, 1863, No. 4.

Gruber, the entire labyrinth and acoustic nerve were wanting. The facial nerve ran in an arched canal through the excessively rudimentary petrous bone.

Anæmia, Hyperæmia, and Inflammation.—Anæmia of the soft parts of the internal ear may occur in general anæmia or in wasting diseases. Without doubt, anæmia produces tinnitus aurium and alteration in the hearing. The latter may be a diminution or an exaltation of the function. In some cases presenting symptoms of general anæmia with tinnitus aurium and morbidly acute hearing, i. e., an apparent hyperæsthesia of the auditory nerve, there may be a tendency to a passive congestion in the labyrinth.

More usual than the symptoms of hyperæsthesia of the labyrinth, are tinnitus aurium and dulness of hearing induced by anæmia. This peculiar state of the organ of hearing I have noticed almost entirely in chlorotic females. Sometimes in females affected with that disease, presenting as its chief features enlargement of the thyroid and other cervical glands, prominence of the eyeballs, and heart disease, deafness may be noticed as a marked symptom. Here, at first glance, one may be disposed to consider the deafness due to hyperæmia caused by obstruction to the circulation, and it may be, indeed, so caused ; but the general impoverishment of the blood has seemed to me to produce changes in the labyrinth in a way similar to that in which other chronic wasting diseases produce their bad results in the ear.

Patients suffering with spinal disease, afflicted with pain and lying in bed for years, are not uncommonly found to be growing hard of hearing. When the spinal disease seems to be arrested, and the patient once more assumes the duties of everyday life, further loss of hearing appears to be stopped. I have been at a loss how to explain these cases, unless it may be assumed that they are of a nervous nature. It must be remembered that the nerve of hearing originates from the medulla oblongata, the highly organized top of the spinal cord, and the latter being greatly implicated in spinal disease may have au effect upon the nerve of hearing. How this operates I do not pretend to suggest, but the cases of deafness occurring with spine diseases are not, probably, as justly placed with catarrhal

affections as with nervous diseases of the ear induced by anæmia and malnutrition during the disease in the spinal column. In progressive locomotor-ataxia it is not uncommon to find complaints made of most vexatious tinnitus aurium and morbidly sensitive hearing, without any symptom in the external, or middle ear to account for the aural disease. It would seem but fair to refer the aural disease in such cases to the cause of the general nervous malady.

Hyperæmia of the Labyrinth.—Recent investigations respecting the histology of the tympanum and labyrinth, have shown the vascular connection between these two parts of the organ of hearing, to be very intimate. It can readily be seen, therefore, how morbid processes in the tympanum may be transmitted to the labyrinth.

Erhard, in 1872, suggested that even so slight a disease as a boil in the external ear, might produce secondary congestion as far inward as the labyrinth.

Prof. Politzer[1] has informed me that he has traced the connection between the vascular tracts of the middle ear and those of the internal ear.

This discovery tends to throw light on many morbid processes in the internal ear. It has often been surmised that disease in the tympanum had passed into the internal ear. It can now all the more surely be supposed that it does, from the new facts presented by Prof. Politzer respecting the vascular relation existing between these parts.

Hyperæmia of the internal ear can be explained, therefore, more clearly than heretofore, and the diagnosis of it is more rational.

Besides congestion of the tympanum as a cause of congestion of the labyrinth, may be cited other causes, either *mechanical* or *systemic*. As an example of the first, may be named the interference to the return current of blood from the head.

Among systemic causes which produce temporary congestions of the labyrinth may be named, the continued fevers, meningitis, and puerperal diseases. Not uncommonly all of the latter causes produce permanent alterations in the important structures of the internal ear.

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[1] Private correspondence, June 26, 1876.

It would seem that a certain kind of congestive deafness, if the term may be used, caused by drinking spirituous liquors, may be placed under this head. Not uncommonly, patients affected with evident catarrh of the middle ear, are made to hear much worse upon drinking a glass of beer or wine.

Here may it not be assumed that the congestion is first in the fauces, Eustachian tube, and middle ear, and from the latter point the hyperæmia is probably extended to the labyrinth?

There is a popular impression that a drunken man is always temporarily deaf, and patients influenced by this idea have inquired whether a daily glass of wine at dinner must be given up in order that everything might be done to improve their hearing.

Whether a drunken man is necessarily a temporarily deaf one, from congestion of his labyrinth, I cannot say, but I am disposed to think the function of hearing may be altered somewhat in such cases, by congestion of the internal ear. However, it is no new observation that a moderate draught of brandy or any alcoholic drink, will produce instantaneous tinnitus aurium and increase of hardness of hearing, in those affected with chronic aural catarrh.

I find, in an old book by Karl Theodor Meneke, published in Hanover, in 1822, a patient's complaint of the above unpleasant result of half a glass of brandy. Intense deafness was produced, and lasted for several hours whenever he thus indulged.

Primary Inflammation of the Internal Ear.—As early as 1836,[1] Deleau pointed out the fact, that too often diseases of the ear—the middle ear as he supposed—were mistaken for diseases of the brain. He then cites five series of observations in proof that certain peculiar sympathies may exist between the diseased ear, and the brain and other organs, as :—

1. Paralysis and convulsions of the muscles of expression in the face.

2. Impairment and loss of reason.

3. Occasional but intense dizziness and cerebral malaise.

4. Frequent and intense vertiginous attacks simulating prodromes of apoplexy.

[1] Bulletin de l'Académie de Méd., Paris, vol. i. p. 234.

5. *Fevers may be brought on which have been termed cerebral.* In the latter instance, probably meningitis is meant by Deleau.

It seems very evident that this observer had seen many cases of aural vertigo, and of that disease so often called Ménière's.

But more definite conclusions respecting the apoplectiform symptoms attendant upon disease of the internal ear, were not arrived at until P. Ménière[1] endeavored to substantiate the following :—

1. "An auditory apparatus, hitherto perfectly normal, may become suddenly the seat of functional disturbances consisting in noises of a variable nature, continuous or intermittent, and which may be accompanied, sooner or later, by a diminution in hearing.

2. "These functional troubles, having their seat in the internal auditory apparatus, may give rise to symptoms which have been considered cerebral, such as intense vertigo, uncertainty of gait, turnings to the right or left, and falling, and they may be attended with nausea, vomiting, and syncope.

3. "These accidents which are of intermittent type, are at last followed by deafness gradually growing worse, and often the hearing is at last suddenly and totally lost.

4. "All this tends to confirm the belief that the lesion which is the cause of these functional troubles is in the semicircular canals."

Ménière's description of an aural disease, contained in these four propositions, is extremely comprehensive, but from the subsequent researches of many others, it cannot be applied to a solitary lesion in the semicircular canals. Neither are these symptoms always the result of a primary disease of the labyrinth. It has already been shown that peculiar vertiginous symptoms, closely resembling those usually called after Ménière, occur as the result of irritation in the external ear. (See p. 326.)

The same fact may be stated as perhaps still more commonly the result of tympanic disease. But symptoms of vertigo, nausea, reeling, without loss of consciousness, etc., with more pronounced and sudden deafness, are notoriously the result of disease of the internal ear or labyrinth, including the nerve of hearing. To this may be added the fact that cerebral tumors

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[1] Bulletin de l'Académie de Médecine, Paris, 1860, vol. xxvi. p. 241.

usually produce symptoms somewhat similar to those of laby-
rinth-disease, yet distinguishable from them.

Primary inflammation of the labyrinth, if traumatic lesions
are left out of the consideration, is extremely difficult to diag-
nose with certainty, and very probably is rare.

There is, however, good reason for believing that primary
inflammation of the internal ear does exist, and has been fully
recognized.

Though, without doubt, two cases of those reported by
Ménière were secondary to previous disease of the middle ear,
the rest of the twelve cases showed signs of a primary lesion in
the labyrinth. In the twelfth case, that of a young woman, a
post-mortem examination revealed such changes in the semi-
circular canals, as to lead Ménière to conclude that the peculiar
train of symptoms, so well known now by his name, were attri-
butable to a lesion in these canals. But pathological founda-
tions for substantiation of this theory, are as yet meagre, though
the labyrinth, in general, is looked upon as the seat of the pecu-
liar irritation in the so-called Ménière's disease. A wider and
juster term would seem to be labyrinthine vertigo, as suggested
by Hinton, of London, or auditory vertigo, as suggested by
Gustav Brunner, of Zurich, or apoplectiform deafness, as sug-
gested by H. Knapp, of New York.

Prof. Voltolini has observed and reported some extremely
convincing cases of a disease closely resembling acute menin-
gitis in young children, but which very probably is a disease
of the internal ear.

From a study of such cases, a fair conclusion may be made
that there is, in very young children, an idiopathic disease of
the internal ear, closely resembling meningitis, but which lacks
the fatal result of the latter; the patient, however, is rendered
permanently deaf. This disease is called, by Prof. Voltolini,
otitis labyrinthica. Thus, a young girl, five years old, with per-
fect hearing, speech, and health, is suddenly attacked with
violent vomiting, which lasts, with intermissions, for several
days; there is also chill and fever. No cause can be assigned
for the illness. On the first day of the disease the child still
hears; on the second day the hearing is found to be entirely
gone, but the intellect is, and *has been* from the first, clear.
Signs are well understood. From the first disappearance of the

hearing, that function has been annihilated. There have been no spasms nor paralysis, and no opisthotonos. The urine and the feces present nothing abnormal. The child may cry out that the noises in the head are distressing. By the fourth day the appetite returns, and the child is found playing in bed. Upon attempting to walk, in the course of two or three weeks, the gait is unsteady, and the child must be led about. An examination of the ear reveals nothing in the sound-conducting apparatus to account for these distressing symptoms.

Such cases, in the opinion of Voltolini, "speak for themselves." "They cannot be either meningitis nor cerebro-spinal meningitis, but must be regarded as a specific disease of childhood—as specific as croup."[1] Drs. Roosa and Gruber are inclined to adopt this view. The mere fact of the rare occurrence of death in the above-described disease, and the absence of important symptoms of meningitis, as well as the permanent deafness resulting, should call attention to the probability that many such cases have been erroneously called meningitis instead of idiopathic inflammation of the internal ear or labyrinth. But, in establishing the presence of such a primary inflammation in the labyrinth, great care must be taken to exclude the existence of a previous disease in the middle ear; for, doubtless many a so-called primary labyrinth-disease is in reality secondary to a tympanic disease, as held by Von Troeltsch,[2] Politzer,[3] and many others. But on this aspect of labyrinthine vertigo more will be said hereafter.

Dr. H. Knapp is disposed to consider the so-called, original Ménière's disease, i. e. the disease ascribed to the labyrinth, and narrowed down to the vestibule and semicircular canals by Ménière, an idiopathic serous exudative otitis interna.[4]

Prof. Moos concludes, from the examination of a number of cases of apoplectiform deafness, that the primary lesion is either in the labyrinth or that it is a paralysis of the acoustic nerve. But, from the observations of this distinguished authority, it can be seen, that it is extremely difficult to be sure that, in every case of supposed primary lesion in the labyrinth, there has been no

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[1] Monatsschr. f. Ohrenh., 1872, No. 8.   [2] Treatise, Lect. 28, p. 516.
[3] Archiv f. Ohrenheilkunde, Bd. ii. p. 91.
[4] Archives of Oph. and Otol., vol ii. part 1, pp. 199–283.

preëxisting tympanic disease. Until the latter can be excluded positively, it is not easy to determine that a labyrinth-disease which has manifested itself, is primary in origin. This dividing line in the diagnosis, makes these cases of so-called Ménière's disease, or labyrinthine vertigo, of greatest interest to the physician.

According to some observers, there is a hemorrhagic process, sudden and acute, occurring as a *primary* disease of the labyrinth. While such a disease may occur in the very robust and florid, as a primary labyrinth-affection, pathological evidence is so far wanting as to excite caution in making a positive diagnosis. Doubtless many cases of apparently hemorrhagic disease of the internal ear occur, as shown by Moos ;[1] but he is disposed to regard even the best defined cases as *secondary* to disease of the middle ear. If, therefore, any trace of preëxisting disease of the tympanum, or of any part of the middle ear or external auditory canal, is found in connection with very manifest symptoms of labyrinthine vertigo, the latter cannot be adjudged as primary. But, if an individual in full possession of positively normal hearing, be suddenly attacked with tinnitus aurium, distressing vertigo, nausea, vomiting, and faintness, the forehead and entire cutaneous surface being at the same time bathed in clammy sweat, but the *mind entirely clear*, and if the gait be unsteady, or the ability to walk entirely gone, with more or less hardness of hearing at the outset, rapidly passing into total deafness, then a diagnosis of acute, primary inflammation, serous or hemorrhagic, may be made.

Causes.—If the diagnosis of a primary inflammatory disease of the labyrinth is hard to establish, the assigning of a cause for it is perhaps still more difficult. In some instances it is evident, as in cases of violence, that the origin of the disease in the labyrinth is traumatic. Perhaps, in some cases, it is due to hemorrhage from atheromatous vessels, the latter being in connection with atheroma elsewhere in the circulatory system.

Treatment.—If the diagnosis of a primary inflammation, of a serous or purulent nature, can be established, the treatment should be conducted on general principles. Calomel and iodide of potassium will, perhaps, render the best aid. If the disease

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[1] Archives of Ophl. and Otol., vol. iii. part 1, p. 118.

appear to be of a hemorrhagic nature, and the subject of it apoplectic in diathesis, then the form of treatment known as depletory should be used. Local bloodletting would be of prime importance. This might be followed by iodide of potassium or the bichloride of mercury, or by both. Here, too, in either form of the disease, is one of the few instances in which a blister over the mastoid, or in front, or about the auricle, may be of advantage. But vesication must be kept up if it is to be of service in these cases. A small, solitary blister is of no avail: it is, indeed, a positive annoyance to a patient, who should be made as comfortable as possible. But a small vesicated spot behind the auricle may be kept up for several weeks. Digitalis and nitrate of silver—but both with great caution—may be given, apparently with advantage.

If it could be known that the intra-labyrinthine pressure of the peri- and endolymph played a great part in this as in other diseases of the labyrinth, then an endeavor might be made to empty the internal ear of its fluid contents by perforating one or both of the fenestræ, as suggested by Dr. Knapp.

Traumatic Injuries.—Fractures of the base of the skull often implicate the temporal bone.

The fissure may extend through the petrous portion, and involve the bony labyrinth, with its delicate and important soft parts.

I examined, not long ago, the skull[1] of a young man, who in sliding on the ice fell, and, striking his occiput, fractured his skull. The line of fracture ran symmetrically through the temporal bones as follows:—

Right Side, viewed externally.—The fracture began in the squamous portion, at a point one-half inch in front of the posterior inferior angle of the parietal bone, ran across the lower part of the squama, then downward, forward, and inward, forming a curve with its concavity downward, across the upper and anterior wall of the external auditory canal, and was lost in the glenoid fissure. *Internally*, the line of fracture began at a point on the upper edge of the temporal bone where the squama fades into the anterior surface of the petrous portion, followed

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[1] Specimen C. 21; Museum of the College of Physicians of Philadelphia.

the anterior edge of the tegmen tympani, and ran through the Eustachian tube, in the long axis of the latter. The fracture had thus separated the anterior half of the osseous Eustachian tube from the posterior, and a portion of the anterior wall of the external auditory canal from the rest of the meatus. The two canals were thus thrown into one. The delicate septum of bone between the carotid canal and the Eustachian tube was intact.

Left Side, viewed externally.—The fracture began at a point similar to that on the opposite side, ran directly forward toward, and in a line with the zygoma, till it reached the point where the latter fades into the junction of the squama and mastoid; here the fracture ran abruptly downward and across the external auditory meatus, dividing the canal equally into an upper and lower part, and instead of losing itself in the glenoid fissure, it ran through the tympanic bone. Internally, the fracture started at a point similar to that on the opposite side, but ran much closer to the ridge of the petrous portion; it ran down through the middle of the tegmen tympani, bisecting the mastoid antrum, tympanic cavity, and the Eustachian tube, and met the line of fracture of the opposite at the spheno-occipital suture. The horizontal semicircular canal was laid bare, but not fractured; it could be seen like an ivory coil lying in the spongy tissue of the temporal bone exposed by the fracture of the mastoid antrum. The internal ear was not fractured on either side. There had evidently been great hemorrhage, as the mastoid cells and sigmoid sinus were filled with hard and dried blood. The ante-mortem notes are wanting.

Prof. Politzer[1] has given the details of a case of fracture of the temporal bones, observed by him in a man, who suddenly fell, striking his occiput on the pavement. Unconsciousness lasted several hours; upon the return of consciousness it was found that the man could not hear nor speak. On the next day, however, the power of speech returned. In the seventh week meningitis set in, and death occurred. The post-mortem examination revealed a fissure at the base of the occiput, extending through both temporal bones, across the vestibule to the inner wall of the tympanum.

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[1] Archiv f. Ohrenh., Bd. ii. p. 88, 1865.

The soft parts of each labyrinth were disorganized; on the right side, the coagulum resulting from the hemorrhage was found nearly unaltered; on the left side, purulent metamorphosis had occurred, and from this point, pus had forced its way through the fracture to the base of the skull, and there produced a basilar meningitis, which had caused death.

Symmetrical fracture of the base of the skull, similar to this case, has been described by Prof. Voltolini:[1] A soldier was struck on the left temple by a billet of wood. He fell stunned; upon regaining consciousness in a few minutes, he vomited, complained of noises in his head, and deafness. There was no hemorrhage from the ear, nor paralysis. Cerebral symptoms supervened, and death occurred on the eleventh day after the injury. The post-mortem examination revealed a fracture extending through both petrous bones, between the round window and the cochlea.

The base of the skull may be fractured; the membrana tympani ruptured; hemorrhage from the ear may take place; there may be facial paralysis on the corresponding side, and yet total recovery ensue, as shown in a case given by Dr. A. Eysell,[2] of Halle.

Symptoms.—In all works of surgery it will be found that one of the symptoms, and a very unfavorable one, too, in fracture of the base of the skull, is a discharge of serum, sometimes tinted with blood, from the external auditory meatus. The serous discharge is generally supposed to be the cerebro-spinal fluid.

If the fracture has implicated the bony labyrinth, it can very readily be understood how an escape of serous fluid may occur from the external meatus. Let it be supposed that such a fracture has not only placed the internal ear in communication with the tympanum, but that the membrana tympani, or the upper wall of the auditory canal, or both, have also been fissured. Thus the fluid contents of the internal ear, shown by Hasse to be part of the cerebro-spinal fluid (see p. 143) will naturally escape, and the internal ear is forever destroyed.

Injuries thus affecting the internal ear may be produced by

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[1] M. f. Ohrenh., 1869; see Abstract by Dr. Knapp, Archives of Oph. and Otol., vol. ii.

[2] Archiv f. Ohrenh., vol. vii. p. 208, 1873.

penetrating violence from without, through the external auditory canal, or by blows and falls.

That force, known as contre-coup, often produces, in the latter instances, the fracture at the base of the skull. When the force comes from below upward, as in a fall, the force of which is communicated through the legs and spinal column to the base of the skull, a fracture may occur only at the latter point, a circumscribed disk of bone being driven upward, as it were, without an extension of the fissure outward to the membrana tympani. In such cases great difficulty will be met in making an accurate diagnosis. Even when the fracture has extended to the membrana tympani and the external auditory canal, thus placing the latter potentially in communication with the internal ear, blood-clots may, for days, occlude the fissure; but sooner or later the cerebro-spinal fluid will make its appearance, in such cases, at the outer auditory meatus.

Although it appears that fractures at the base of the skull, involving the petrous bone, may not prove fatal in every instance, the hearing is permanently destroyed by such an injury.

Mr. J. Hutchinson[1] has reported a case of fracture of the petrous and squamous portions of the right temporal bone, without laceration of the dura mater. Acute arachnitis occurred over both sides of the brain. On the day following the fall which produced this injury, there was found a watery discharge from the right ear.

Mr. Hutchinson states that inflammation of the subarachnoid space is more likely to occur, than arachnitis, after injuries to the head, in which a drainage from one ear has ensued.

Another case from this observer, is as follows :—

A boy fell down stairs, was stunned, and bled from right ear, and was deaf on that side. On 2d day was conscious but stupid; still deaf on right side. 3d day. Pulse 80, irregular; feverish; peevish and restless; tongue coated; serous discharge from ear. 4th day. Worse; very restless; no paralysis; pupils dilated and fixed. Near midnight violent convulsion, in which he died. At the autopsy, fracture of the petrous bone was found. Lymph in the subarachnoid spaces at base of brain and around pons and medulla.

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[1] Lancet, London, 1875, vol. i.

It is very evident that disease of the internal ear has been, for a long time, considered a result consequent upon other diseases.

Itard names five causes of secondary changes in the auditory nerve, in all probability meaning by the latter the entire internal ear. These causes are thus given by him:[1] *Concussion of the nerve, convulsions, apoplexy, fevers, and sympathetic influence of some other diseased organ.*

Deafness from Concussion.—Deafness from concussion is no uncommon occurrence. The following cases will illustrate the general features of such accidents.

CASE I. Mr. R., banker, age thirty-eight, single, states that eight years ago he was thrown from his horse. Was made senseless for some time; upon recovering consciousness he found that he was absolutely deaf in the left ear, and has remained so ever since. Taste and smell were greatly impaired; but they gradually returned, taste first, and then the sense of smell. The latter, however, has never been as sharp as it was before the accident. The inspection of the left external ear and membrana tympani presented nothing abnormal. The deafness was absolute.

CASE II. A young man, nineteen years old, standing on a moving railway-train, was struck on the head as the train passed under a bridge. He was picked up and carried home in unconsciousness. Upon the recovery of consciousness, it was observed that he was deaf in both ears. His family think he could hear a little when he first became conscious, but in a few days he was certainly absolutely deaf. His voice assumed a most peculiar and unnatural clang. Upon inspection of the drum-heads it was found that they presented nothing to explain the deafness. The diagnosis in such cases is most easily made to be paralysis of auditory nerve, from concussion of the labyrinth, perhaps chiefly of the cochlea.

CASE III. A boy was struck on the external ear by a hard snow-ball. He became totally and permanently deaf on that side. The drum-head appeared normal.

[1] Maladies de l'Oreille, Paris, 1821, p. 311.

CASE IV. A young druggist is standing with some friends near a party of men firing salutes on the fourth of July; while his back is turned to the guns, the discharge occurs, and he instantly observes a buzzing and deafness in one ear. This continues for some days, but the hearing is not entirely gone; care and some general tonic treatment seem to do good, and gradually the subjective noises in the ear cease, and the hearing grows sharper and finally is restored. But these cases do not usually terminate so favorably. Whatever is done for them must be done promptly.

CASE V. An Irishman, forty years old, states that he became deaf in his left ear from an accident which happened to him while helping in laying cobble-stones in one of our streets. He states that in lifting the long, heavy pounder these men use to drive the stones down, he lost his balance, and the force of the blow seemed to spend itself on the left side of his body and head. He noticed immediately that he was deaf, and he has remained so. The drum-heads present nothing to explain the deafness, and the case was apparently one of deafness from concussion.

Dr. Brunner[1] has recorded the case of a man thirty-six years old, who fell and struck the left temple; the man lay for some time insensible; he was picked up and carried into his house, where he lay in unconsciousness all night. There was some bleeding from the nose and left ear. Upon regaining his consciousness he was unable to speak or to write, and there was paralysis of taste on the left side, the latter attributable, according to Dr. Brunner, to an injury of the chorda tympani. The power to speak and write returned in the course of three weeks. The sense of taste returned gradually in the course of four months. The hearing, at that length of time after the fall, was $\frac{1}{150}$ cm. for the watch.

Respecting convulsions, Itard states that this cause of deafness is very rare in the adult, but very frequent in infancy. When the hearing is lost in the first three or four years of life, it is generally in consequence of convulsions. A number of infants, who had become deaf at the period of dentition, had, for the most part, ceased to hear immediately after a light convulsion. I have seen a number of mute children who were supposed to

[1] Archiv f. Ohrenh., Bd. vi. p. 32.

have become deaf in consequence of convulsions. Upon closer investigation there was no history of cerebro-spinal meningitis, and I am inclined to believe that the cause assigned by the parents, "fits," was the true explanation of the destruction of hearing. Most writers are in accord that the following diseases produce secondary results in the labyrinth : cerebro-spinal meningitis, mumps, and syphilis ; typhoid, intermittent, and other continued fevers ; the exanthemata, and some skin diseases about the head, as erysipelas ; the puerperal state, and its diseases.

Hardness of Hearing, and Total Deafness after Cerebro-Spinal Meningitis.

—Hardness of hearing and total deafness frequently occur as sequelæ of cerebro-spinal meningitis, a fact noted by all writers on the nature and course of this fever.

In a recent epidemic in the Philadelphia Hospital,[1] occurring in 1866–67, deafness existed to a greater or less extent in sixteen cases. In twenty-four cases observed by Fassett, referred to by Stillé, one-half recovered ; but three of them with entire loss of hearing, and one with partial deafness as well as strabismus.

Dr. Knapp[2] had an opportunity of seeing seventy-one cases of deafness, and fourteen of blindness, mostly in children under ten years of age, the result of epidemic cerebro-spinal meningitis in New York, in 1872–1873. He states that "the deafness or blindness was, in most cases, first noticed during the first or second week of the fever ; in rare cases the deafness set in during the mostly protracted period of convalescence, and, exceptionally, even so late as *six months* after the beginning of the cerebro-spinal inflammation. In these latter cases, however, some hardness of hearing was observed when the patients had so far recovered that their hearing could be tested. The hardness of hearing then increased slowly, and terminated in complete deafness within some weeks or months."

In the majority of cases the patients are found to be entirely deaf when they recover their consciousness. During the febrile stage, or during convalescence, it appears, from the observations of Dr. Knapp, that the pharynx and middle ear may be con-

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[1] See "Epidemic Meningitis, or Cerebro-Spinal Meningitis," by Prof. Alfred Stillé, Phila. 1867, p. 71.

[2] Deafness from Epidemic Cerebro-spinal Meningitis. Trans. Amer. Otol. Soc., vol. i. p. 448, 1873.

gested or inflamed. These symptoms may subside, but the hearing once lost is never recovered. This observer also notes that when at the first examination the hearing was found impaired in consequence of the meningitis, it went on diminishing to total deafness.

Dr. Levi[1] has noticed that the membrana tympani of those becoming deaf in consequence of cerebro-spinal meningitis, may assume a chocolate hue. But I am not aware that this has been noted by any other observer. This peculiar color was seen by Dr. Levi only in the lower segment of the membrana tympani. A symptom noted by all is the deafness of both ears. According to Prof. Roosa, both meningitis, and cerebro-spinal meningitis may lead to disease of the labyrinth by direct transmission of the inflammatory action. Disease of the middle ear also results from those affections, and in many cases these two parts of the ear may be simultaneously affected.[2]

But according to the observations of all, the labyrinth is the part most usually attacked by meningitis. The nature of the lesion is supposed by some to be suppuration of the labyrinth (Lucæ, Haller, Knapp), but by others is not thus explained, as there are not enough post-mortem proofs of such a lesion.

According to Prof. Roosa, it seems probable that the seat of the lesion is to be found in the labyrinth proper, and not in the auditory nerve-trunk, for the facial nerve is seldom affected.

Von Troeltsch is disposed to place the lesion in the fourth ventricle of the brain, from which the auditory nerve springs. (Work on the Ear, American edition, 1869, p. 511.) We learn from the work of Prof. Stillé, already referred to, that "the ventricles are the seat of effusion in many cases;" the nature of this may be serous (Stuart), aqueous (Jackson), purulent (Ames), a limpid fluid (Craig), and sero-purulent (Armstrong and Clarke), while Klebs has found the fourth ventricles and the aqueduct of Sylvius fully distended by thick yellow pus.[3]

According to the investigations of Weber-Liel and Hasse (see p. 143) it is fully established that the sub-arachnoid cavity and the labyrinth are in direct communication, the endo- and peri-lymph of the latter being really part of the arachnoid

[1] Maladies de l'Oreille. Paris, 1872, Plate iii. Nos. 29 and 30.
[2] Roosa, op. cit., p. 500.   [3] Stillé, op. cit., p. 81.

fluid.　By this means, as Dr. Hasse justly observes, morbid processes may be communicated from the brain to the ear, or *vice versâ*.　Now, it is one of the marked anatomical features of this disease that the arachnoid tunic is constantly found altered by the morbid process.　Lymph and pus may be found between it and the brain, as has been fully demonstrated by many post-mortem examinations.　It would seem highly probable, therefore, that in this disease the morbid process is conveyed from the brain to the ear by continuity.

In a case observed by Moos, the hearing failed on the third day ; the other symptoms ceased on the ninth day, and four days later the hearing began to improve.　It is stated by Moos,[1] that, in the cases terminating favorably, reported by Ziemmsen and Hess,[2] the hardness of hearing began mostly on the third day.

After a careful dissection and microscopical examination of the internal ears in a case of cerebro-spinal meningitis, which proved fatal thirty-six hours from its inception, Prof. Lucæ[3] found the hemispheres, base of the brain, pons, and medulla affected by a purulent inflammation of the pia mater.　The microscopic examination traced the purulent inflammation along the auditory nerve to the cochleæ.　Purulent inflammation of the sacculi, ampullæ, and canals of the membranous labyrinth was also found ; along their vessels were masses of pus-cells and free blood-corpuscles ; the vessels were intensely congested and much thickened ; the semicircular canals also showed occasional ecchymoses.　The tympanic cavities, except a slight injection, were normal.　The fibres of the facial nerve were subjected to microscopical examination, but were found to be normal.　In the ampullæ and sacculi were here and there deposits of fat and chalk.　Prof. Lucæ concluded that it was probable the disease began first in the brain and then passed to the ear.　In the same article it is stated that Heller[4] found, in a case presenting similar disorganization in the labyrinth, purulent inflammation of the middle ears.

[1] Archives of Oph. and Otol., vol. i.
[2] Deutsches Archiv für Klin. Med., 1865.
[3] Archiv f. Ohrenheilk., vol. v.
[4] Archiv f. Klin. Med., Bd. iii. s. 482.

In some cases there appear to be gaps in the power of hearing :[1] thus, speech is heard very imperfectly, while the patient's own step and loud noises in the street are heard comparatively well. The low notes on the piano are not heard in some of these cases. This seems to indicate that parts of the terminal nerve-filaments have been impaired, while others have escaped. When some hearing still remains, hope of further recovery may be entertained if the treatment be applied promptly. This has seemed most efficacious, according to some observers, when consisting in the application of the constant electric current, after Brenner's method.

The tone lacunæ, or gaps in the hearing, were very marked in a young man seventeen years old, whom I examined several years after his recovery from an attack of epidemic cerebro-spinal meningitis. He could not hear the voice of others, but he heard his own. He could easily perceive some sounds, as the cracking of a whip (he was a storekeeper in a rural district), the rolling of heavy carts past his door, etc. His voice was peculiar, and wanting in timbre, like that of the deaf mute. The intellect was good, and his capacity for business well known. Electricity, applied in Brenner's way, made no improvement; very probably, because applied too late.

The staggering gait is usually noted only, at first, in those who have been made deaf by cerebro-spinal meningitis. This sequel was marked in a little boy six years old, whom I saw six weeks after convalescence. The deafness was absolute. In walking, his gait was sailor-like, and he assumed the peculiar attitude of those on shipboard, in order to steady himself. The staggering gait does not remain, however, as the deafness does.

Prognosis and Treatment.—The prognosis is always highly unfavorable. The treatment, certainly in the early stages of the deafness, would naturally be the treatment carried out for the cure of the primary disease. After convalescence from the meningitis, electricity in the form of the constant current, and the administration of strychnia, either internally or hypodermically, have been thought to be of value, if there is any

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[1] S. Moos, Peculiar Disturbances of Hearing after cerebro-spinal meningitis; considerable Improvement by the Galvanic Current. Archives of Oph. and Otol , vol. i. pp. 332–340, 1869.

remnant of hearing. But they are not usually attended with satisfactory results, and if the hearing be entirely gone, they are powerless to restore it.

Disease of the Internal Ear from Syphilis.—Although the majority of writers upon syphilis, agree that the ear is often affected in the constitutional form of that disease, aurists have not felt warranted in making such assertions.

Prof. Schwartze,[1] who has written the best paper on this subject, states very justly that "the question to be decided is whether the aural diseases which occur in the course of constitutional syphilis, possess distinctly characteristic and ever-recurring anatomical and clinical peculiarities. Only by proving that such is the case can it be positively shown that a given ear-disease is of a specific nature." He further regards the recovery of an aural affection, in consequence of an anti-syphilitic treatment, as inadequate proof of the origin of the ear-disease. After considering syphilitic affections of the external and middle ear, he alludes to syphilitic diseases of the nervous apparatus of the ear. Six cases are given, four of which were affections of one side only. The characters of these were, intra-cranial paralysis of the acoustic nerve, anæsthesia of the left acoustic nerve, in consequence of otitis interna syphilitica, and paralysis of both acustici, from double otitis interna syphilitica.

Some of these cases were benefited in their hearing, by anti-syphilitic treatment, which is considered by Prof. Roosa, in cases observed by him, as establishing the syphilitic nature of the disease of the internal ear.

The possible occurrence of syphilitic disease of the internal ear has also been shown by J. Hutchinson, Lucæ, Hinton, Politzer, and Knapp.

My own experience leads me to consider the invasion of the internal ear by syphilis, as extremely rare.

Symptoms, Prognosis, and Treatment.—The chief symptoms are sudden deafness, accompanied sometimes by paralysis of other parts of the body, and by vertigo, nausea, and unsteadiness of gait. Tinnitus aurium is more or less constant, and may, with sensations of fulness and beating in the ear, precede the deafness.

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[1] Archiv f. Ohrenh., vol. iv. p. 253.

Headache is generally complained of, the scalp being very often, in such cases, the seat of a cutaneous eruption of a more or less markedly specific nature. The prognosis is not favorable; if the syphilitic nature of the disease can be established, the treatment, of course, should be an anti-syphilitic one.

Disease of the Internal Ear from Typhoid Fever.—In some instances it would seem that the internal ear had been affected by typhoid fever. But the vast majority of cases thus diagnosed appear, on closer investigation, to be diseases of the tympanum. A labyrinth-affection must be considered, so far as it follows typhoid fever, as at most secondary to a tympanic disorder. As I have observed a number of neglected cases of tympanic inflammation following typhoid fever, I am led to conclude that it is in the middle ear, rather than in the labyrinth, that an aural disease after typhoid begins. A chronic aural catarrh having such an origin is as likely to be incorrectly diagnosed as nervous or labyrinthine, as it is when arising from other causes. By neglect of the tympanic disease, a labyrinthine disorder may be established. Hence, the erroneous impression that the labyrinth has been the seat of the primary affection.

Aural Vertigo from Chronic Catarrh of the Middle Ear.—In considering the symptoms of acute catarrh of the middle ear, vertigo occurring in it has been already alluded to, and a possible explanation of it given.

It cannot, however, be said that in such cases the vertigo could ever be confounded with the more typical variety found in the so-called Ménière's disease.

Under the term aural vertigo from chronic catarrh of the middle ear may be included those cases which might be called light forms of Ménière's disease. The irritation is doubtless in the middle ear; a reflex action is communicated apparently to the internal ear. But as yet no serious lesion has occurred there.

A high degree of deafness is wanting in these cases, and their onset is slow. Since they lack the suddenness of all the symptoms of aural vertigo, caused by a more direct lesion in the internal ear, they are not very difficult of recognition.

Thus, a car-conductor, 28 years old, comes with the statement

that he has noted for a year or more, whenever he is exposed more than usual, and catches cold, he has great roaring in one ear, then dizziness, nausea, fainting, and vomiting—with relief. This occurs in a short space of time, perhaps while at the depot, and he is able to run his car at the appointed time. The drum-head is somewhat opaque, the hearing is impaired, but by no means destroyed. The throat and fauces are catarrhal. Treat-ment of the fauces and Eustachian tubes diminishes the tendency to vertigo.

Another case is that of a gentleman, 55 years old. He states that he has been deaf in the left ear twenty years, but became much worse after a severe cold about eight years ago. It was during the latter attack of ear-disease that he noticed the spells of vertigo and nausea, which usually occurred at the table. This probably indicates a high degree of irritability of the pneu-mogastric. As spring came on, and the catarrhal deafness diminished, the vertigo became less frequent, and less intense; but ever since the attack of increased deafness, each winter finds him suffering with throat and ear disease, and frequent attacks of vertigo with noise in the ear, on the left side chiefly. Both ears are diseased, the membrana tympani being perforated on the right side, but now cicatrized; on the left side, the mem-brane is intact, but opaque and retracted. To this side he refers the cause of the vertigo. The tuning-fork not heard in either ear, through the bones. The hearing for the watch was—

$$\frac{\text{4 cm. right ; 20 cm. left.}}{\text{50 ft.}}$$

The treatment was begun Dec. 4, 1873, and kept up for a month. It consisted in applying nitrate of silver in solution to the mouth of the left Eustachian tube, and in inflations of the tympana by Politzer's method, together with catheterization of the left Eustachian tube. The latter seemed to give most relief, as that tube was decidedly narrowed. There was no attack of vertigo during the treatment, and throughout the winter the patient was free from it. This would seem to show that here the vertigo was caused by catarrhal disease of the middle ear. The hearing was not improved to any great extent.

But there are on record a few cases, though doubtless many others have occurred, which have been recognized, but not re-corded in literature, in which all the above-named symptoms of

labyrinthine disease have existed, excepting the high degree and permanence of the deafness. Mr. Hinton records such cases,[1] with the statement that the recovery of hearing was perfect. He, therefore, raises the question, "Were they not caused by muscular spasm?"

Aural Vertigo with Variable Hearing.—Especially noteworthy is that form of acute aural vertigo in which the hearing diminishes during the paroxysm, improves during the intervals, and finally is recovered, when the paroxysms of tinnitus, vertigo, etc. cease to recur. In such cases it is manifest that the direct lesion cannot be in the labyrinth, and the question may be asked, Are not such cases due to a spasmodic affection of the muscular structures of the middle ear? Future investigations may show that such cases are produced by undue inward pressure of the foot-plate of the stirrup, brought about either by a tonic contraction of the tensor tympani, so powerful as to overcome the equilibrium normally existing between the latter and the stapedius muscle, or, perhaps, by a relaxation of the latter, thus permitting the normal tensor tympani to act without the antagonistic counterbalance of the stapedius muscle.

As tending to answer in the affirmative the question thus proposed, I would cite the following case :—

Mr. X., 41 years old, single, a stock-broker, was brought to my door in a carriage, on May 8, 1875, apparently in collapse. Upon approaching him, however, he was found to be perfectly conscious, but very pale and weak, and his surface cold and clammy. I was asked to accompany him immediately to his home, and, while doing so, learned from him that he had been suddenly attacked about an hour previous, while attending the meeting of the board of brokers, with sudden and intense tinnitus aurium and vertigo, with entire inability to stand, and that he had at last vomited; but during all of this most disagreeable attack, his mind had been perfectly clear. I may state that the patient's moral character is above the slightest suspicion. I found his pulse about 75, but weak, and he stated that there was still some vertigo, but that the buzzing in the ear had given place to a "stunned feeling" in the head, attended with a boring sensation, which seemed to start behind the auricle, and to extend inward to the centre of the head—a symptom often

[1] Questions of Aural Surgery, pp. 261–262.

mentioned by patients presenting the general train of so-called Ménière-manifestations. There was no complaint of altered hearing at this time, but I found that the watch was heard only $\frac{6}{60}$ in. by the affected ear.

The patient was put to bed, a little warm brandy and water was given him, as his surface was very cold, and warmth was applied to his feet. In about an hour the vertigo became very much less, the head was more comfortable, and the face lost its intense pallor. Pulse 80. The patient then stated that, four or five weeks previous, he had noticed occasional attacks of slight tinnitus in the left ear. This was increased somewhat by cold air blowing on the ear. In a week or two later he observed some dizziness with the tinnitus, and also some confusion in hearing, especially during the playing of the organ and the singing in church. The patient had a good musical ear, and he heard all notes sharpened, i. e. heightened in pitch, in the left ear, which, of course, produced subjective discord with what he heard in the good ear. This was also true for the tuning-fork (small a) with which I tested him; it seemed higher in pitch in the left, the affected, ear. As the tinnitus passed off, however, notes appeared once more to have their true pitch in the affected ear.

With the cessation of the tinnitus, and with the return of the power, in the affected ear, to hear notes in their true pitch, the hearing also improved for the watch, rising from $\frac{6}{60}$ in. during the attacks to $\frac{20}{60}$ in. as the paroxysms ceased. This occurred not only *once*, but *repeatedly*, and it was also observed that a mantel clock, easily heard by the patient across the room in the affected ear, when unattacked by the above paroxysms, was not heard during the latter.

The left membrana tympani was more retracted than the right. The Eustachian tubes were pervious; the fauces, normal. The patient remained in bed four days. On the first day it was observed that rest in a reclining posture relieved the tinnitus and vertigo; on the second day, however, a severe attack came on in bed, and lasted several hours; on the third day an attempt to rise brought back all the symptoms, finally relieved by vomiting; on the fourth day, another severe and long attack occurred; on the fifth day, the patient observed the "stunned" feeling in the side of the head as alternating with the tinnitus. The

latter invariably preecdes the attacks of vertigo, beginning as a low and distant singing or ringing, and increasing to a loud roaring, which culminates in the vertigo and nausea.

On the sixth day there was no attack; on the seventh, he felt very much better till 11 A. M., when another severe paroxysm occurred. As a rule, the attacks occurred always in the afternoon or evening; on the eighth day, there was no attack, but on the ninth there was a not very severe one. · Again on the tenth day there was no attack, but at midnight of the eleventh day there was a very severe attack of vertigo, which woke him up. Closing his eyes had always aggravated the vertigo, and now he found that the darkness of his room greatly increased his dizziness, and being entirely unable to help himself he was obliged to call for a light in order to gain some relief from the terrible discomfort brought about by the vertigo. He felt that his whole body was being borne through space. Usually the apparent motion of surrounding objects during the attacks, was around the patient from right, over his head, to left, under him, and up again to the right. The severe attack of vertigo of the eleventh day extended into the twelfth, but the patient did not vomit.

On the thirteenth day he had two attacks, but they were short and not severe; there was no vomiting. On the fourteenth day there were again two attacks, but they were light, and there was no vomiting. On the fifteenth day there was no attack, but on the sixteenth there was one very light and short paroxysm of tinnitus and vertigo. On the seventeenth day there was none, but on the eighteenth there was a very slight one, which was the. last the patient had. The hearing now became normal.

The patient had been under intense mental excitement (and his general health had failed) from the time of the financial panic of 1873 to the date of his attack of vertigo. He had also been, in his weakened, nervous condition, obliged by his business to endure the intense and peculiar noise of the brokers' board, and also to strain his ears to catch, and his vocal organs to perform his share of, the bidding which goes on in such places.

The treatment consisted in general support with good food, and some alcohol, together with large doses of bromide of potassium during the prevalence of the paroxysms. As the latter

diminished in severity and frequency, iron and quinine were given. On the sixth day of the disease, when its spasmodic features were fully shown, twenty grains of bromide of potassium were given every hour, which was continued until the tenth day, when but ten grains were given every hour or two. On the sixteenth day the bromide was taken every three hours, and kept up in this way until the paroxysms ceased to occur.

The patient then went to Europe, made a short tour, and returned to business in the autumn, about six months after his first attack of vertigo.

There has been no severe return of these attacks; in the spring of 1876, however, when he was under considerable mental excitement once more, he had a slight return of the tinnitus, and a tendency to vertigo, but no sickness of the stomach. These symptoms came on just exactly one year after the former severe ones. A few days of rest, and from six to eight grains of quinine daily, dissipated all these unpleasant warnings, and the patient was soon able to resume his work.

This case of aural vertigo is especially interesting on account of the variable hearing which was so prominent among the symptoms during the disease, and also on account of the recovery of hearing, which ensued as soon as the paroxysms of tinnitus, vertigo, nausea, etc. ceased to recur. These features of the disease would tend to place it either in the list of those of unfrequent occurrence, or else among those the true nature of which is not recognized, and hence undescribed.

The case of Mr. X. presented all the prominent symptoms usually found in labyrinthine vertigo, excepting the sudden, total, and permanent deafness. But the want of this latter symptom would exclude it entirely from aural vertigo due to labyrinthine disease. It was certainly not caused by any irritation in the external auditory canal, and it is entirely out of the question that it could have had its origin in cerebral tumor, because such a supposition is unwarranted by the symptoms, and the finally good result obtained in the case. May it not be, however, classified as aural vertigo of a tympanic variety, in which the primary lesion lay most probably in the muscular structures of the tympanum? As tending to cause such a disturbance may be mentioned the intense strain on the vocal organs, as well as on the muscular accommodation of the tym-

panum, which necessarily occurs among those frequenting the brokers' board meeting, where bidding aloud and listening to bids go on.

From the observations of James Hinton,[1] respecting "labyrinthine vertigo, sometimes called Ménière's disease," it is also made evident that a perturbed perception of musical notes is a marked symptom of this affection, *g* of the third octave being heard twelve notes lower, or as *c* of the octave below. The note most distinctly heard in this case was g^{iv}. The following conclusions may also be drawn from the cases observed by Mr. Hinton:—

1. It appears that in some instances the hearing power is worse at the time of the paroxysms of giddiness and vomiting. In others, the hearing power is at once impaired, and remains so, or is observed gradually to improve.

2. All the marked and serious symptoms may be present, and yet recovery finally occur.

3. Tinnitus in these cases may be due to muscular spasm, either in the tensor tympani, or in the stapedius muscle.

Aural Vertigo resulting from Secondary Inflammation of the Labyrinth.

—The symptoms generally known as those of Ménière's disease, or labyrinthine vertigo, which very probably occur sometimes in consequence of a primary lesion in the labyrinth, most certainly are observed in connection with secondary processes in the internal ear. They are more usually the result of the latter than of the former disease, as can be shown by reference to cases which are recorded in the literature of the subject of aural vertigo, and by observation of those occurring constantly in the experience of every physician. Perhaps most of the cases recorded as Ménière's disease come under this head. The diseases to which labyrinthine vertigo is most likely to be a secondary result, are those of the tympanic cavity, as acute or chronic catarrh, or chronic purulent inflammation. Such cases might well be considered, as suggested by Brunner,[2] transition-forms of Ménière's disease, in which the chronic aural catarrh obviously existed as the primary affection.

[1] Guy's Hospital Reports, vol. xviii., 1872.
[2] Archives of Oph. and Otol., vol. ii. pp. 293–342.

Even the most marked symptoms of so-called Ménière's disease may be traced to disease of the tympanum, as is shown in the following case,[1] which occurred in the practice of Dr. Wm. Pepper, Clinical Professor of Medicine in the University of Pennsylvania, to whose courtesy I am indebted for the opportunity of examining the aural features of the case. Dr. Pepper's notes in the case are as follows :—

"Nov. 11, 1873, John French, aged fifty; a large, heavy, strong man; works in a rolling-mill at Trenton, N. J.; of temperate habits, and without suspicion of venereal taint. Enjoyed good health until the spring of 1871. Once he observed that, on walking home in the evening, his gait became irregular, and he pitched awkwardly. In June, 1871, he was suddenly seized in the mill, while sitting down, with a sense as though ' the whole mill was coming down,' and then he immediately pitched forward on the ground, hurting himself on the flag pavement. He thinks he did not lose consciousness. It was five minutes before he could get up, and he was unable to work for six months. He noticed immediately, ringing in the left ear, like the roaring of a sea-shell, or sometimes like a little bell. For some months he vomited occasionally, usually immediately before being seized with a dizzy fit. He vomited severely with the first attack. Since that time he has had very numerous similar spells, all occurring suddenly without warning; he is then seized with sudden, extreme vertigo, seeing all surrounding objects whirling *around* and also rising up into the air; at the same time he feels something moving or running through his head; the ringing in the left ear increases, and seems to extend upward to the left temple, and, on reaching there, he instantly falls to the ground violently and without any power of controlling the direction of his fall, so that he has frequently hurt himself severely. Still, there is never the least loss of consciousness. He knows he is falling, sees the ground and surrounding objects, and when he reaches the ground usually cries out to any one near at hand that he is not hurt and will get up in a few minutes if let alone. He feels intensely giddy while on the ground, for from two to five minutes; is then able to get up, and, after sitting for ten or fifteen minutes,

[1] Reported by the author to the American Otological Society, 1874.

feels as usual again, or merely a little weak and shaky. These attacks occur very irregularly as to frequency, severity, hour of day or night, season, etc. Occasionally he passes two weeks without a spell: at other times he has them very frequently. His eyesight is good; appetite good and regular, with fair digestion. Needs a laxative pill occasionally. Sleep is irregular when he does not work. Has been in the habit of being freely cupped (by order of other physicians who treated the case as epilepsy) behind ears and at back of head, having from six to eight fluidounces of blood drawn every month or three weeks; also dry cups on temples. At first, this relieved the sense of fulness and giddiness, but lately it has not afforded much relief. Patient is not troubled with palpitation of the heart."

The *treatment* consisted in small doses of iodide of potassium, to which were added small doses of digitalis. After being on this treatment for about two months, Dr. Pepper ordered nitrate of silver, in doses of $\frac{1}{3}$ gr. thrice in twenty-four hours. This was taken for two months, and produced apparently the greatest freedom from the attacks of vertigo. But, as the man began to show signs of growing worse, he was ordered to take iodide of potassium (4 gr.) and bichloride of mercury ($\frac{1}{16}$ gr.), with compound syrup of sarsaparilla, upon which mixture he remained for several months. This was succeeded by nitrate of silver, $\frac{1}{3}$ gr. in pill; but again he was placed on iodide of potassium, which he continued to take until his recovery seemed assured.

On the 11th of November, 1872, I examined the ears of this man, and made the following notes, to which others of a later date have been added.

The drum-heads presented unmistakable evidences of chronic catarrh of the middle ear. Their lustre had disappeared, and they were thickened. On the left side there was absolute deafness for external sounds, with constant tinnitus, " like the roaring of a sea-shell." On the right side, the hearing for the watch $\frac{10}{60}$ ft.; for voice, five paces, confirming the supposition of previous aural disease, based on appearances of the drum-heads. Tuning-fork vibrating on the vertex, heard only on the right, *i. e.* the better side. Eustachian tube, with difficulty pervious to inflation by the catheter, on the left side. Before the first attack of vertigo and falling, the patient weighed two hundred

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and forty pounds, but now his weight is one hundred and eighty-five pounds. Formerly, the ringing or "roaring of a sea-shell" moved slowly upward toward the vertex on the left side just before an attack of vertigo; but subsequently this was not so marked, and he no longer had this warning of an attack.

The next time I saw the patient was 18th February, 1873, three months after the first notes of his case. He looked much better, but felt weak; still had attacks of vertigo, which were not more severe, however. The tinnitus continued without change, and at this visit I applied the constant electric current of Brenner: 12–16 el. (S. and H.), 2100 R., positive pole, ball-electrode in the meatus of affected ear. This increased the tinnitus. The negative pole was then applied to the affected ear, the number of elements increased to twenty, and the tinnitus was diminished greatly. The patient stated that the ringing apparently left the interior of the head, moved to the meatus, and then to the auricle. He subsequently stated that he felt this relief for several hours after the visit.

Apparent Motion during the Vertigo.—During the vertigo objects appear to revolve in an antero-posterior direction, in a vertical plane. There is a total loss of equilibrium, but consciousness is perfect. The attacks come and go suddenly, and are followed by a cold sweat. Since the apparent motion of surrounding objects seemed to cause considerable distress to the patient, the suggestion was made to him to close his eyes at the next attack, which he did; but he stated that he felt the motion in the already described meridian, just the same.

During these attacks, when he feels that he, with all surrounding objects, is revolving from before, backward in a vertical plane, he says that he does not seem to revolve any further than a point at which he appears to have been placed on his back, i. e., if he is in a vertical position when attacked, he seems to move backward or to be dragged backward 45°, while objects about him seem to rise from the floor or ground and revolve in a circle about him. The attacks of vertigo increased in frequency about May 1, after which he had one spell characterized by apparent motion in a horizontal plane from left to right, at which time, instead of falling backward, he fell toward the right, with the apparent motion.

The first thing which attracts the attention, in this case, is

the probability that a so-called chronic aural catarrh existed on the left side before the attack of labyrinthine vertigo. Chronic aural catarrh most surely exists now on the right side, and as the membranæ are similar in appearance, each presenting unmistakable evidences of the aforesaid disease, I believe the left side had been affected by chronic catarrh some time before, which in all probability induced the vertiginous attacks by an extension of disease to the labyrinth, and perhaps to the semicircular canals.

It is also very interesting to note the various planes of the apparent motion experienced by the patient during the attacks of vertigo, and the length and character of the arcs of the apparent meridians described, both by the patient's body and surrounding objects. Most of the attacks of vertigo, always accompanied by perfect consciousness, were characterized by an apparent motion in a vertical plane from in front backward, *i. e.*, in the plane of the superior semicircular canal. Once the apparent motion was in the plane of the horizontal or inferior semicircular canal. The apparent motion was always felt, even when the patient closed his eyes, a clinical fact, entirely in harmony with the experimental observations of Mach.[1] At the time of the attacks of vertigo, the apparent or subjective motion of the patient's body, ceased when he reached the ground, and lay upon his back, although the apparent motion of surrounding objects continued.

The paroxysmal nature of the vertigo, with temporary increase of the tinnitus, in an already diseased ear, would seem to indicate that whatever the cause of the irritation is, it is not constant nor totally destructive of the part chiefly attacked.

This case presents a collection of clinical phenomena, partly of a subjective nature, most strikingly in accord with the recent investigations[2] of Mach, Breuer, Cyon, and Curschman, all of which have added facts tending toward the conclusion that, although the semicircular canals may not be devoid of acoustic functions, they seem to possess well-marked functions of presiding over the pose of the head, and *mediately* over that of the entire body.

The man who suffered as described above, finally recovered

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[1] Page 154.   [2] Pages 153–156.

from the liability to be attacked by vertigo, but he remains totally deaf in the left ear.

Vertigo from Cerebral Tumors.—I have seen lately two cases of tumor in the brain, one proven post-mortem, the other diagnosed as such, but still living, in which the new growth produced symptoms very like those of labyrinthine vertigo. Still, there were points of differential diagnosis in these cases, inasmuch as the first, a woman, suffered for many years with most of the distressing symptoms of labyrinth-disease, with the exception that she became *slowly* entirely deaf, whereas, as has been said, the deafness of true labyrinthine disease is sudden, intense, and permanent.

Further account of this case will be given when considering sarcoma of the auditory nerve.

In the other case, that of a man, the presence of a tumor of the brain has been diagnosed. The patient has some of the symptoms of aural vertigo, but there is permanent alteration of the gait, which is not characteristic of Ménière's disease, nor of any form of aural vertigo originating in the tympanum or external ear. Furthermore, he is not very hard of hearing, and though he has constant tinnitus in both ears, and frequent attacks of giddiness, the latter are always relieved by sitting down. Although these cases might be classed under aural vertigo, they are manifestly not cases of labyrinthine vertigo, known as Ménière's disease. In fact, they present a train of symptoms sufficiently distinctive of a morbid growth in or pressing upon the auditory nerve and cerebellum.

CHAPTER II.

MORBID GROWTHS OF THE AUDITORY NERVE.

THE auditory nerve is more frequently the seat of morbid growths than any other cerebral nerve, as shown by Virchow. Such formations are usually of a fibrous or sarcomatous nature; the nerve may also undergo amyloid degeneration.

Fibrous Tumors.—Fibrous tumors of the auditory nerve may be idiopathic in origin, but more usually they are found in connection with caries of the temporal bone (Gruber). Such growths have also been described by Landiforth and Lévêque-Lasource, as stated by Moos.[1]

Boyer[2] describes a case of what was termed by him "cancer of the occipital fossa." In this instance, the morbid growth invaded and destroyed the auditory nerve, as it did most of the nerves distributed to the right side of the head. The subject was a man, 33 years old.

Carré[3] observed a case of what he termed cancer of the annular protuberance (pons Varolii) in a man 29 years old; the hearing was diminished; at the post-mortem examination, the auditory nerve was found pressed upon, but not destroyed.

Sarcoma.—Cases of sarcoma of the auditory nerve have been observed by Voltolini and Förster.[4] In the case given by the former, a sarcoma filled the entire left internal auditory canal, and the auditory nerve was destroyed. In the case observed by Förster, a sarcoma as large as a goose's egg had sent off a peg-like process into the left internal auditory canal, which was enlarged.

Other cases presenting more or less striking symptoms of sarcomatous growths in the auditory nerve, have been recorded by Cruveilhier,[5] Moos,[6] and Boettcher.[7] The latter denominated the growth observed by him, fibro-sarcoma.

Symptoms.—It would appear from the published accounts of the occurrence of this form of cerebral tumor that it is found most frequently in females. The ages of those affected vary from seventeen to forty-nine years. The duration of the disease, counting from the earliest symptoms, may extend over seven or eight years; though it may run its full course in a

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[1] Archives of Oph. and Otol., vol. iv. 1874.
[2] Bulletins de la Société Anatomique, 9 series, 1834, p. 273.
[3] Ibid., p. 115.
[4] Würzburger Med. Zeitschr., 1862 ; see Moos, Archives of Oph. and Otol., p. 484, vol. iv.
[5] Anatomie Path., livraison 26 ; see Kramer "Die Erkenntniss, etc. der Ohrenh.," 1849, p. 858.
[6] Loc. cit.
[7] Archives of Oph. and Otol , vol. iii. pp. 134, 171, 1873.

year, as shown in a case recorded by Moos. The cause of this disease of the auditory nerve has been supposed to be due, in some cases, to exposure to cold; but the most frequent causes, as stated by Virchow, are mechanical injuries to the head and syphilis.

The earliest and most striking symptoms are tinnitus aurium and failure in hearing, with more or less dizziness; these are followed by greater deafness, increased noise and distress in the head, and dizziness on motion, with consequent uncertainty of gait. Then there may come a period of relief and apparent recovery from most of these symptoms, excepting the hardness of hearing. But, sooner or later all the above symptoms return and become aggravated; the power of controlling the limbs, both upper and lower, fails; pain in the head is intense and lasting; the dizziness grows worse; the patient walks with legs apart, inclining to one side in walking; and nausea and vomiting may occur. In some cases, facial paralysis occurs quite early in the disease, and there may be anæsthesia of the mucous membrane of the nose, as noted by Moos. Not uncommonly there are symptoms of chronic aural catarrh in the ear corresponding to the side on which the auditory nerve is invaded; and this has often misled in making a diagnosis. Finally, the general nutrition of the patient begins to fail; the strength goes; diarrhœa may supervene; or the patient may sink into coma, and die with or without convulsions.

Through the kindness of Dr. Morris Longstreth, Pathologist to the Pennsylvania Hospital, I have had the opportunity of consulting the ante-mortem notes, and of aiding in the post-mortem examination, of the following case of *tumor of each auditory nerve*:—

Catherine C., admitted to the medical wards of the Pennsylvania Hospital on October 12, 1874. Is an American by birth, but of Irish parentage; is forty-two years old; single, and a seamstress. Has always been well until within a year of her admision to the hospital, when she took a severe cold in the head. She also began to have at this time pain in her forehead and vertex. In the previous June her hearing began to fail rapidly, until she became very deaf. Then there supervened tinnitus aurium, *unsteadiness in gait*, pain in her limbs, impairment of sensation in the legs, vertigo, and occasional nausea. There

had never been any loss of power in the limbs, nor muscular trembling.

On Nov. 1st, when Dr. James H. Hutchinson[1] took charge of the ward, it was noted by him that there was a tendency on the part of the patient, when walking, to fall forward and to the right, and that on some occasions she had fallen. Attacks of vertigo could be induced, in the erect position, by closing her eyes; but she was free from them when lying in bed. There was great pain in the head, generally referred to the vertex and to the forehead over her eyes. The tinnitus aurium continued very intense and annoying; it was, however, paroxysmal, *being worse in the morning.* There was nausea, but no vomiting.

There was no loss of power in the limbs, nor paralysis of any of the cranial nerves, and no disturbance of sensibility at that time, as noted by Dr. Hutchinson. She was deaf, but not absolutely so. There was no history nor suspicion of syphilitic taint. The physical condition of the Eustachian tubes and tympana was found, by Dr. R. M. Bertolet, to be normal.

The ophthalmoscope revealed, in the *right eye,* "indistinct outline of disk; *left eye,* changes more marked, viz., outline of disk obliterated, veins much enlarged and curved at margin of disk, which is redder than normal, vessels not usually seen being distinctly visible towards its outer side."

The subsequent history of this woman shows that she was deafer at some times than at others: the right ear was better than the left (post-mortem examination revealed on the left auditory nerve the larger tumor); there was headache, falling, with inability to rise, loss of power to assist herself, and, finally, confinement to bed. There then ensued loss of power over legs, failure of intellect, and difficulty in swallowing. Muscles of eyeball prolapsed; pulse and respiration increase in frequency; cyanosis of face; involuntary evacuation of urine. Disks of both eyes become indistinct in outline; there is impaired sensation of extremities; unconsciousness and death supervene. Temperature, a few hours before death, 106° F.

Two hours after death an examination was made by Dr. Morris Longstreth, to whom I am indebted for the following notes:—

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[1] See Phila. Med. Times, May 8, 1875.

The thoracic and abdominal viscera were normal, in general; the only point to be noted was marked congestion of lung, with a small area of pneumonia in left lower lobe. Only one kidney was found, the right one, weighing nine and a half ounces.

The cranium was normal, except the conditions noted below in relation to the internal auditory meatus and jugular foramina.

Dura mater was normal, excepting two small spiculæ of bone in the neighborhood of the falx cerebri. Arachnoid membrane normal. Pia congested. Cerebral convolutions were flattened, especially at convexity. At the base, the floor of the third ventricle was bulging downward and fluctuating.

On the left side, behind the petrous bone, below the tentorium was a large tumor, pressing on the left hemisphere of cerebellum, left half of pons, and left crus cerebri. The nerves springing from the left side of the medulla oblongata, passed on the under surface of this tumor, were flattened by it and somewhat adherent to it.

The left eighth pair (auditory and facial) winds inward, forward, and then downward around the tumor, to which it is tightly adherent, and by which it is flattened into a ribbon-like band, appearing transparent. The two divisions of this nerve could not be separated without destroying them, as their consistence is so much reduced.

This tumor measured two inches transversely; one and three-quarter inches antero-posteriorly. It was lobulated, and made up of cysts with solid intervening structure-like partition. Some portions were reddish or pinkish (cystic); other parts white, firm, and opaque.

This tumor extended along with the eighth nerve into the left internal auditory meatus, which was considerably widened. The nerve ran along the forward and inner part of the canal, whilst the projection from the tumor-mass was on the outer and back part of this tube. In the removal of the brain the left nerve with the tumor was cut through at the surface of the petrous bone, thus separating part of the tumor and leaving it within the internal auditory canal. After removal of the brain, there was quite unexpectedly found a *second* tumor, resting on and adherent to the posterior surface of the *right* petrous bone. It was oval in shape; five-eighths of an inch long, extending along the bone; seven-sixteenths of an inch in its vertical

diameter, and of doughy consistence. It was attached by a sort of pedicle, which was found to extend into the right internal auditory canal. Its consistence was considerbly greater than the larger tumor, on the left side, and the eighth nerve was more intimately united to it. As its presence was not known until after the removal of the brain and the division of the nerves was made, it is not known positively what relation it sustained to the eighth nerve; but, apparently, the nerve-trunk ran under it to reach the internal auditory meatus. The tumor had, as on the other side, considerably enlarged the porus acusticus internus. The bone was not uncovered, the dura mater being still adherent but thinned. The right eighth nerve, from its origin, seemed of normal size and consistence.

The cochleæ were carefully dissected from the petrous bone by myself, and were prepared for microscopic examination by Dr. Longstreth. When the latter had made the sections, we examined the microscopic conditions most carefully, and the results of that investigation are here given.

Microscopical Examination of Left Cochlea.—The tumor on the left petrous bone, as already described in the post-mortem record, had pressed flat the nerves entering the porus acusticus on this side. The new growth had, by pressure, enlarged the opening and bulged into it for some distance, making the internal auditory canal funnel-shaped. There was no evidence that the growth extended in the nerve-trunk itself, or that it had reached the fundus of the canal. The canal was occupied by an increase of connective tissue substance toward the base of the cochlea. The walls of the internal auditory canal were covered by a thin periosteum; the bone was everywhere covered, and presented no erosion or roughness.

The shape of the modiolus was normal. The spaces in its substance, which normally are occupied by divisions of the cochlear nerves, show no trace of nerve-fibrillæ or ganglia. At one point is seen some exceedingly delicate fibrous tissue arranged in a regular, wavy manner. Many of the spaces contain granular and fatty detritus, showing in its midst a few fine fibres, by which the material is held in place in connection with the walls of the spaces; these fibres take somewhat the form of a network. Others of the spaces are nearly free of

contents, showing sometimes a scant fibrous network; sometimes the space is crossed by a delicate bony trabecula. A number of vascular lumina are here visible, often to be recognized by their corpuscular contents; their size is small and their number not great.

The lamina spiralis ossea is normal in shape; the space between the lamellæ of bone contains no trace of nervous tissue, but is occupied by a very fine fibrous material, containing in it much less granular matter than similar tissue in the spaces of the modiolus with which it is continuous.

The membrana basilaris is not sufficiently well-preserved in any of the sections to admit of a particular description. The pieces of it that were examined, however, showed no marked changes. Nothing was seen of Corti's organ.

The ligamentum spirale externum of Henlé was normal in appearance. The lining cubical epithelium of both scalæ was very distinct, and presented a smooth, even surface. The bone at all parts presents, microscopically, perfectly normal conditions.

Microscopic Examination of Right Cochlea.—The tumor has grown deeply into the internal auditory meatus, which is dilated from atrophy of its wall by pressure. This atrophy extended markedly towards the base of the cochlea, reaching close up to or into the modiolus, where parts of the tumor in mass may be seen. In consequence, the bony parts between the scalæ and the fundus of the internal auditory canal are rendered thin.

The modiolus does not present the characteristic form, and differs in shape also from that shown in similar sections taken from the opposite cochlea. The alteration is more noticeable in parts nearer the summit, and is partly due to new material extending within the scalæ, and partly to a change within the bone itself; whether this is from an extension of the tumor, or from other changes in the bone, was not determined.

The bloodvessels were not a conspicuous feature in the modiolus; they certainly were not increased in number, nor were their lumina exaggerated. A number of them contained corpuscular elements. The bone-tissue at this portion was normal in appearance. The ganglionic spaces in the modiolus presented a markedly different picture from those on the opposite side; they contained a granular, amorphous material or cell-structure.

No appearance of new fibres, nor indeed of fibrous material, was made out. Near the junction of the lamina spiralis ossea with the modiolus these spaces became larger, and the cellular nature of their contents was more distinctly to be seen. In some sections this cellular material seemed directly continuous with the material deposited within the scalæ.

The lamina spiralis ossea presented about the same appearance in all the sections, and was unchanged in form. The space between the bony lamellæ of the lamina spiralis showed no nervous structure, but contained granular material pretty dense in character. The demarcation between the osseous lamellæ and the space itself was very distinct; the lamellæ themselves, except in their rigidity, gave no characteristic bony appearance. They took the staining of chromic acid quite deeply, whilst the granular material between was nearly cleared of color by washing and soaking in oil of cloves. In one or two places only, in all of the sections, was seen, between the lamellæ, a trace of fibrous tissue.

At the habenula perforata there are no nerve-fibres to be recognized. The *membrana basilaris*, in sections equally delicate with those taken from the opposite side, is much better preserved in the right cochlea than in the left. It shows sometimes in cross section, sometimes in mass, giving a profile view of some extent of its surface; sometimes it is in connection with the ligamentum spirale, sometimes it is torn loose from this connection, and is lying free in the scala; again, it is crumpled up by the separation of the ligamentum spirale from the outer bony wall. In none of the sections does it appear to have any of Corti's organ in relation with it. In some of the specimens there seemed to be a thickening or a growth developed upon this membrane, as will be spoken of below. Corti's organ, except in one doubtful instance, is not to be seen, even in a fragmentary condition, in the preparations. I do not mean to imply that Corti's organ was destroyed or wasted, but simply state the fact that, in carefully treated specimens, no certain trace of it was discovered.

The membrane of Reissner was, of course, not preserved; only its ends of attachment at the outer wall and at the lamina ossea were represented by a trace of tissue.

The membrana tectoria was seen in a more or less fragmentary

condition in all the specimens, attached to the extremity of the labium vestibulare, while the other end of it was not in connection with any tissue, but floated freely in the ductus cochlearis. In the sulcus spiralis was seen in some specimens a small collection of material, mostly of a granular nature, although sometimes it presented distinct cell-elements, not unlike in appearance those seen at other parts, whose origin from the new growth was undoubted.

Concerning the scalæ, it was noted that, when the cochlea was first laid open, a material was seen by the naked eye within them, placed at the junction of the lamina spiralis ossea with the modiolus, and both above and below the lamina, i. e., in both the scala vestibuli and the scala tympani. With the microscope, this material is very conspicuous in all of the sections examined, and it is more abundant in the scala tympani. In places, there is seen a connection or continuity between the new growth within the spaces of the modiolus and that of the scalæ. This material shows an extension of itself along the fibrous covering of the lamina spiralis ossea. In no instance does it extend, however, to the membrana basilaris, although in some specimens there can be seen an unevenness of the epithelial lining of the scalæ.

At the outer wall of the cochlea, especially at the ligamentum spirale and its stria vascularis, there was more material of nearly the same appearance; it was never seen in masses, projecting into the cleared spaces, but showed as a roughness and irregularity of the lining membrane. This change was chiefly in the ductus cochlearis on its outer wall. The change was not limited merely to the surface, but showed itself in the deeper parts, and the condition was more apparent in instances where the ligamentum spirale had been dragged and separated from the outer bony wall. The effect of this new material was to give an appearance of greater thickness to the ligamentum spirale, especially near its union with the membrana basilaris. In some specimens it appeared as though this material extended along the membrana basilaris; in no instance was it seen in continuity with similar changes on the lamina spiralis ossea, but was coexistent with such a condition. As far as the membrana basilaris itself was concerned, the change appeared limited to the upper (ductus cochlearis) surface; although the limitation of the

material to this surface could not be affirmed positively in cross sections, other specimens seen in profile from below showed no material to be present on the under (scala tympani) surface. No good or distinct profile view of the floor of the ductus cochlearis was obtained.

No examination with gold solution was made for the presence of nerve-fibres, as this test, as is universally conceded, is value-less, except when carried out in perfectly fresh tissues. In-numerable pigment-masses were seen at the periphery of the sections, and in the modiolus, such as have been seen on other occasions in bone treated with chromic solution and acid for the purpose of decalcification. May not this be the origin of the " brownish pigment, mostly deposited in multipolar cells," de-scribed by Boettcher as occurring in a similar position ?

This case, as well as the one about to be given, will furnish many points of guidance in establishing a differential diagnosis between Ménière's disease, or labyrinthine vertigo, and the vertigo associated with permanent alteration in the gait, very often observed in cases of cerebral tumor.

Feb. 1, 1876.   James L., aged 35, laborer, Irishman, was admitted to the wards of Prof. J. M. Da Costa, in the Pennsyl-vania Hospital. The patient admits having had a chancroid ten years previous, but denies all secondary symptoms, and none can be found. Six years previous to admission to the wards he had suffered from malarial fever, for which he had taken large doses of quinia without poisonous effects, but he had been sali-vated. His health had been good up to seven weeks before entering the hospital, but he took cold at that time from expo-sure, had a severe coryza, and in less than a week he had noticed buzzing in his ears, vertigo, staggering in his gait, but *no altera-tion in hearing.* When he would sit or lie down, his vertiginous symptoms would vanish. Headache was complained of, and nausea and vomiting had occurred at times.

On admission to the hospital, it was found that there was a depression in the skull at junction of sagittal and coronal sutures, but no other evidence of *violence* to the head; he could give no account of the origin of the depression in the skull.

Pupils were normal; tongue extended straight; voice high pitched; patient cheerful; the hearing was found to be for the

watch, on the right side $\frac{12\ \text{in.}}{4\ \text{ft.}}$; on the left side $\frac{5\ \text{in.}}{4\ \text{ft.}}$. There was decided loss of sensation and power on the left side, in arm and leg. Electro-muscular contractility was not impaired; slight loss of co-ordination; he could walk with eyes shut as well as open; stands poorly on one leg, but picks up small objects well.

He walks with his legs far apart, tending to the left side, towards which side he easily falls. Stands with legs widely separated, for when erect he soon leans towards the left; the least push would then throw him toward the left side, whereas he was quite firm when pushed in any other direction. Dimness of vision had been noted by patient; the ophthalmic examination made by Dr. W. F. Norris showed slight haziness, and striation of the retina in each eye.

The urine was high colored, and slightly turbid; sp. gr. 1021; acid; no albumen; no sugar; there were traces of urates. Occasionally severe pain in back of head, relieved by bromide of potassium; vertigo felt only in the upright posture; feels a subjective, not an objective, uncertainty in walking. No murmur in temporal or mastoid region. Such were the general notes on the ward-book.

Aural Notes.—Both drum-membranes were normal in lustre, color, and tenuity; not the slightest congestion in them anywhere.

Inclination of membranes nearly normal; left (deafer side) a little more retracted than right. The former, therefore, shows less of a pyramid of light than the latter.

Under the pneumatic speculum the left moves more readily than the right membrane. Hearing for watch L. $= \frac{1}{60}$; R. $= \frac{1}{5}$.

Speech is heard relatively much better than the watch. This would seem to indicate integrity of the cochlea. Patient said he heard a vibrating tuning-fork placed on his vertex in both ears. Eustachian tubes perfectly pervious, as shown by Eustachian catheter. Hearing was not altered by inflation of tympanum.

Unusually severe sneezing was caused by the introduction of catheter; he thought his ears buzzed a little more after examination. Vertigo and gait were in no way changed by manipulation and examination.

He says he is dizzy whenever, and only whenever he attempts to walk, and relief is always obtained by sitting down.

There was considerable naso-pharyngeal catarrh, but the Eustachian tubes were pervious, as stated. There was no evidence of accumulation of mucus in the tympanum, and the external auditory canal was entirely normal. Nothing, therefore, was found in either of these parts of the ear to account for the peculiar symptoms in this case. If the man's statement be true, that his hardness of hearing, peculiar vertigo, and altered gait came on at the same time, it would look like a case of so-called aural vertigo, but every well-marked case of vertigo from aural irritation is *paroxysmal* as to the onset of dizziness, reeling, falling, etc. Some tinnitus, and usually considerable alteration in hearing remain, but the gait is never *permanently* changed.

Pathological Changes. — In a case recorded by Moos,[1] the post-mortem examination revealed a tumor of the left auditory nerve, which had caused compression of the pons cerebelli, and of the left oculo-motor, the fifth, and the facial nerves; there was also gray degeneration of the spinal cord. The condition of the organ of Corti was one of fatty change, and partial destruction. In the case of Cruveilhier referred to, there was found under the tentorium cerebelli on the left side, a hard nodulated tumor, which pressed upon the left half of the pons, the medulla, the peduncles of the cerebellum, and upon the cerebellum itself. The tumor hung by a stout pedicle over the posterior surface of the petrous bone. The seventh pair of nerves were destroyed at the porus acusticus.

Fibro-Sarcoma.—Dr. Boettcher,[2] of Dorpat, writes of *fibro-sarcoma* of the auditory nerve as of no uncommon occurrence. But he believes, that the microscopic changes in the labyrinth in such cases have usually escaped attention. Fortunately for otology, the article on the case referred to is offered by its distinguished writer as the beginning of a pathological histology of the cochlea.

In the case of a young woman, 21 years old, who died in consequence of the cerebral tumor, the morbid growth was found connected with the common trunk of the facial and the auditory

[1] Archives of Oph. and Otol., vol. iv. p. 484.

[2] On Changes in the Retina and Labyrinth in a case of Fibro-sarcoma of the Auditory Nerve. Archives of Oph. and Otol., vol. iii. pp. 134–171, 1873.

nerves. The latter appeared like a white cord, 2 cm. long, and 1 mm. thick, showing under the microscope, medullary nerve fibres in all its fasciculi, but the medullary sheath was nowhere complete.

The great denudation of entire fasciculi of axis-cylinders, noted in this case, was considered very extraordinary. All the fibres were colored by chloride of gold, intensely violet. Fatty degeneration was not discoverable in the specimen mounted in alcohol. Part of the tumor extended into the porus acusticus internus. This canal was found dilated in all directions by the morbid growth. This was deemed simply the result of atrophy from pressure.

At the bottom of the internal auditory canal, where the tumor was found in contact with the base of the cochlea, the growth bulged toward the modiolus.

Not a trace of nervous elements remained in the modiolus. An absence of the nerve fibres was also demonstrable in the spiral canal of the modiolus. The lacunæ once occupied by the spiral ganglion were empty.

Changes in the Vestibule and Semicircular Canals.—"Here the epithelium, and connective tissue-envelope of the sacculi, and membranous canals were well preserved; large and numerous vessels were observed in the envelope. The macula and the cristæ acusticæ were unaltered in form, but no nervous fibres were seen to enter these structures."

The facial nerve was present from the angle of, and filled the bony canal. The ganglion geniculi was found to be atrophied. There was facial paralysis on the corresponding side. The tumor was classed by Dr. Boettcher among the fibro-sarcomata.

Glioma.—Brückner[1] has described a cerebral tumor, which occurred in his wife, in whom the suspected cause was a fall on the back of her head on the ice, in her thirteenth year. "The first symptoms of the disease were noted about three years later, in the form of uncertainty in the use of her upper and lower limbs. Four years before her death, which occurred when she was twenty-eight years old, a diminution of hearing upon the left side was accidentally noticed, with giddiness and catarrh

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[1] Berliner Klin. Wochenschr., No. 29, 1867.

of the middle ear; and, finally, complete deafness."[1] A singular phenomenon in this case was that, three or four months before death, a whirring, like the placental murmur, could be heard by applying the ear directly to the patient's left temple; once, very feebly on the right temple; the sound ceased to be heard by herself or others after she had taken large doses of iodide of potassium. The left auditory nerve was found to be entirely obliterated, and in its place there was a large glioma.

The Labyrinth in Ileo-Typhus.—By post-mortem examination, Prof. Moos[2] found in the labyrinth of a soldier who had died of ileo-typhus or typhoid fever, a large quantity of lymphoid corpuscles on the lamina spiralis membranacea, on the sacculi and the ampullæ. Some of these had undergone fatty degeneration. They were most numerous in the region of the point of entrance of the cochlear branch of the auditory nerve, into the labyrinth.

Fatty metamorphosis of the organ of Corti, closely resembling that found in sarcoma of the auditory nerve, may also be the result of hemorrhages into the cochlea, as shown by Moos.[3]

Amyloid degeneration of the auditory nerve has been fully described by Förster[4] and Voltolini,[5] and its occurrence corroborated by Lucæ and Politzer. It appears to be of common occurrence, as stated by Gruber.

Corpora Amylacea.—Certain bodies found in the semicircular canals of man, are considered by Lucæ[6] to be of a pathological nature and as peculiar to the adult. It is claimed that they are never found in the new-born child, but that they are produced by local disturbances or by general systemic diseases in advanced life.

These products, or amylaceous structures, are found in cases

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[1] Moos, Archives of Oph. and Otol., vol. iv.

[2] Ueber die Anatomischen Veränderungen des Häutigen Ohrlabyrinths bei Ileo-Typhus. Verhandl. d. Naturwiss. Med. Vereins zu Heidelberg, v. 169; also M. f. O., No. 2, 1872.

[3] Archives of Oph. and Otol., vol. iv. pp. 497–502, 1875.

[4] Atlas of Pathological Anatomy, p. 86, 1854.

[5] Virchow's Archiv, vol. 22, p. 114, 1861.

[6] Virchow's Archiv, Band 54, Heft 1.

of gray degeneration of the spinal cord, typhus, tumor of the brain, tuberculosis, Bright's disease of the kidneys, peritonitis, chronic ulcer of the stomach, and in those in whom an aural disease has been present up to the time of death. It is furthermore asserted that these bodies are never found in the lower mammals, birds, fishes, or amphibia, which is considered by Prof. Lucæ as additional proof of their pathological nature.

So far as the occurrence of these bodies in the diseases mentioned above is concerned, it may be said, as Rüdinger has already suggested, that it is rather *post hoc* than *propter hoc;* for it is just such diseases which supply material to the anatomist for his investigations; and hence, if they are normally present, these subjects in common with all others should present examples of the so-called corpora amylacea.

Hallucinations of Hearing in the Insane.—Hallucinations of hearing are common in the insane. They are very often not dependent upon any aural disease; though in many instances they seem to have been induced by a disease in the ear. In some instances, after the removal of a plug of cerumen or other morbid cause of the hallucinations, the latter have been diminished, but not entirely removed. They have been noted in women afflicted with nymphomania. In such, the hallucination has been the supposed hearing of a man's voice, which, as Dr. O. D. Pomeroy[1] has observed, indicates rather a disease of the nervous system than of the ear. Still, whenever insane patients complain of subjective hearing, their ears should be examined, for a removal of the aural irritation, if one should exist, may relieve, if it does not entirely banish the hallucinations.

Prof. Moos[2] found an enlargement of the bulb of the jugular vein in the right petrous bone of an insane man, who had suffered with the most intense and distressing noises in the ear, and to escape which he finally committed suicide.

Prof. Moos thinks that when blood passed from the lateral sinus into the enlarged bulb of the jugular vein, vortices must have been formed in the current, and in consequence thereof a

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[1] Hallucinations of Hearing in the Insane, Trans. Amer. Otol. Soc., vol. i. p. 184, 1871.

[2] Archives of Oph. and Otol., vol. iv. pp. 479–482, 1875.

blood murmur must have been produced, which on account of its nearness to the labyrinth must have been heard as a loud subjective noise. In this account, allusion is made to the theories of Oppolzer, Friedreich, and Boudet. They explain the tinnitus of chlorotic patients as a subjective perception of the *bruit de diable*, because it disappears usually on compression of the carotid. Prof. Friedreich has not found this rule invariable.

I have known an insane woman to be distressed and made worse by the imagined hearing of an infant's cry. As she could not stop the imagined cry of pain, that of her own child, whose death had caused the insanity, the brain symptoms became markedly worse. The ear was not examined in this case.

An insane man, with normal ears, once or twice presented himself for treatment to gain relief from sounds of a peculiar kind, "spirit voices," which he seemed to hear in the air above his head. These sounds were not always disagreeable to him, but were annoying by their long continuance, and by their preventing sleep. The ears were carefully examined in this case, but nothing whatever abnormal was found in them.

Nervous Deafness.—Strictly nervous deafness must be regarded as among the greatest rarities. Among the peculiar nervous symptoms which sometimes attend acute articular rheumatism, may be found a form of acute deafness, which might be called nervous. At the same time hysterical symptoms may manifest themselves.

Dr. S. Weir Mitchell has called my attention to what he terms hysterical deafness. In the case of a young woman he observed a deafness, which would apparently come and go during conversation. At other times, the patient would fail to hear under circumstances in which she had but a short time before appeared to hear well. I have never observed such a case, but I doubt not that such should be classed under hysterical phenomena.

Moos[1] observed a case of intra-cranial disease after acute rheumatism, with peculiar nervous phenomena, combined with complete deafness for noises, musical tones, and speech. The

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[1] Archives of Oph. and Otol., vol. i. p. 464.

patient was communicated with by writing, for several weeks. Under the use of the constant electrical current, the patient entirely recovered.

When it is remembered that there is a close connection between acute articular rheumatism, chorea,[1] and meningitis, it can be understood how the hearing might be either temporarily or permanently affected by the rheumatic poison.

Total deafness may be the result of a fall brought on by dizziness from causes other than aural. This fact must be carefully borne in mind in estimating the part the ear may have had in the production of the primary disease, as is shown in a case given by Moos,[2] as follows: A soldier suddenly fainted and fell, without any previous warning. Upon the return of consciousness, he was found to be entirely deaf to all sounds. Subjective noises were noticed at first, but they gradually ceased. Dr. Moos was led to believe that, in consequence of the fall, an extravasation of blood took place at the origin of both auditory nerves; in no other way can the total and sudden deafness be accounted for. Fracture of the bone would in all probability have produced death. The precise seat of the extravasation was supposed to have been in the medulla oblongata, at the point of origin of the deep root of the auditory nerve.

Respecting diagnosis and prognosis in this and similar cases, Prof. Moos says: "In cases of considerable impairment of hearing, or total deafness, no prognostic value can be attached to auditory sensations occasioned by the application of the constant current. If, however, a repeatedly applied galvanic current of such intensity as will cause twitching of the muscles of the face and the extremities, fail to produce sensations of hearing, we may infer the existence of complete paralysis of the auditory nerve, and form an unfavorable prognosis."

The Effects of Quinine upon the Ear.—The question is often asked, Does quinine cause ear-disease—Does it make one permanently deaf? And the answer, so far as I am able to give it, is always in the negative. I say this with all reserve, and

[1] Germain See; De la Chorée, Paris, 1850.
[2] Archives of Oph. and Otol., vol. ii. pp. 199-203, 1871.

with the full knowledge that many high authorities[1] have taken an opposite view, and have, as they believe, adduced proof of its correctness. Wherever quinine has been supposed to be a cause of deafness, usually it can be shown that the disease for which the drug has been given is the underlying cause of the failure in hearing. It is most positively known that malarial diseases—chills and fever—for which large doses of quinine are usually given, are frequently followed by hardness of hearing and deafness, whether quinine be given or not. But yet malarial disease often runs its most virulent course, and quinine is also given in large doses, without the production of deafness.

In the case of a young physician, cited by Dr. Roosa as one of aural disease probably caused by quinine, there was not only history of throat- and naso-pharyngeal disease, but also of malarial taint. There were also intense neuralgia and general debility, just such symptoms and diseases as would be treated by quinine. The supposed causative connection between the giving of quinine and paroxysms of pain in the ear must, I think, be regarded as occurring after, but not in consequence of, the administration of one of the most valuable drugs the physician can resort to.

A great many patients think they are deaf in consequence of taking quinine; but in all such cases which I have observed, there was most evident cause for the deafness, in catarrhal disease of the naso-pharynx and throat, which antedated the administration of quinine. In many cases, the diseases for which the quinine had been given, as puerperal diseases, continued fevers, chest-diseases, etc., were much better known to be causes of deafness than the taking of the drug in question.

It is admitted that quinine will cause ringing in the head and ears as well as temporary hardness of hearing. It is supposed to be due to congestion of the nerve. But were quinine injurious to the ear, its ill effects could be plainly seen when given to those affected with aural disease. On the contrary, a partially deaf person may be made temporarily deafer, but when the quinine is no longer taken, the hearing returns to its

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[1] Dr. Roosa, Trans. Amer. Otol. Soc., vol. i. p. 276; also vol. ii. p. 93; also M. Mélier, Mémoires de l'Académie Royale de Médecine, p. 722, quoted by Drs. Roosa and Hammond.

relatively normal point. Furthermore, some kinds of tinnitus aurium, viz., from anæmia and debility, are stopped by taking quinine. Of course, poisonous doses of quinine, like any other morbific element introduced into the blood, might have a bad effect on the nerve of hearing and perhaps on the sound-conducting parts too. But, so far as my experience goes, all necessary doses of this useful drug can be given in any case with impunity whether the ears are affected or not. And I base my belief on the observation of about 1600 cases of ear-disease in Philadelphia, besides upon the large numbers I have seen in the clinics of Europe.

In the later paper by Dr. Roosa,[1] upon his investigations into the effects of quinine upon the ear, made upon and in conjunction with Dr. Hammond, it would appear that sometimes *congestion* of the external ear occurs as the result of the administration of this drug.

Dr. Roosa believes " that tinnitus aurium and impairment of hearing following the use of quinine, depend upon congestion of the ultimate fibres of the auditory nerve in the cochlea, and that the redness of the drum-heads is merely an index of the former condition."

But it does not yet appear to be established that the administration of quinine does produce disease of the sound-conducting parts, *i. e.*, of the external ear or drum-cavity.

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[1] Transactions American Otolog. Soc., vol. ii. p. 93.

SECTION VII.

DEAF MUTES AND PARTIALLY DEAF CHILDREN.

CHAPTER I.

METHODS OF RELIEF AND EDUCATION.

DEAF-dumbness may be either congenital or acquired. In some instances the two forms may be united, as shown by Moos.[1]

Recent investigations by Luys[2] into the structure of the central nervous system, have led him to locate the sense of hearing in the posterior lobes of the cerebrum, in which theory he believes himself further strengthened by the condition of the brain in two deaf mutes.

In one, an intelligent man 72 years old, who had died of pneumonia, some of the inner convolutions of the posterior lobes of the cerebrum were atrophied, yellowish, and at points œdematous; on the right side these changes were more marked than on the left side. The white fibres of the brain, which connected these parts with the optic thalami, the point deemed by Luys the centralizing area of all outward nervous impressions, were traversed by growths of connective tissue, and had undergone amyloid degeneration. At the optic thalami only, the posterior nuclei were infiltrated by serum, soft, and amyloid. The gray substance about the aquæduct of Sylvius presented a similar condition. The remainder of the brain was normal, but the acoustic nerve was atrophied at spots.

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[1] Archives of Oph. and Otol., vol. ii. p. 138, 1871.

[2] Contributions à l'étude de lésions intracérébrales de la surdi-mutité, Ann. des malad. de l'oreille, 1875, pp. 313–322. See A. f. O., B. xi. p. 179 ; abstract by Kuhn.

In another mute, 14 years old, a similar condition was found. Dr. Kuhn states that Hunter[1] has also described quite extensive changes in the optic thalami in a case of absolute deafness.

The congenital form of deaf-dumbness has generally been considered as the commoner occurrence. In comparatively few instances its existence has been proven by post-mortem examination to have been due to malformation of the internal ear or of parts of the brain. Knowledge as to its true nature and cause would be greatly enhanced by more thorough records, in deaf and dumb institutions, of the condition of the ear during life and a complete description of its state, as revealed by post-mortem investigation.

Beard and Roosa[2] have placed the average of congenital deaf-muteness at about sixty-one per cent. of all cases of mutes; Wilde placed it at fifty per cent.

By a reference to the reports of the last three years, of the Pennsylvania Institution for the Deaf and Dumb, Philadelphia, it will be found that one hundred and thirty-seven children were admitted within that time, who lost their hearing from fever and other causes, and had in consequence become dumb. They constituted *two-thirds* of the entire number of admissions, thus showing that, in this institution at least, *congenital* deaf-muteness is considerably less frequent than the acquired form.

It is held by Von Troeltsch that an hereditary tendency to deaf-dumbness exists in some families. Within a very short time I have seen a family in which four children were deaf mutes. But it appears from the investigations of modern times that the *acquired* form of deaf-muteness is by far more common than was once supposed.

In many instances the history of a case points to a destructive disease of the sound-conducting parts in the tympanum and also in the labyrinth, at a very early period of extra-uterine life. But even in these lamentable cases, to state that the sufferer came into the world endowed with the power to hear, is often a grain of comfort to parents who cannot bear to regard a child as congenitally defective.

Every physician may be called upon to decide whether a child is deaf and dumb, and if it be, to suggest, if not a cure for the

[1] Transactions of Medico-chirurg. Soc., London, 1825.
[2] Op. cit., p. 515.

deafness, at least a plan for the proper education of the little patient.

In very young children it cannot be readily decided whether total deafness exists or not. But whether a child is totally deaf or not, it may be too deaf to learn to talk by hearing others speak. It is not unusual to find pupils in deaf and dumb institutions, who can hear loud sounds, and even the human voice when shouted into their ears.

Without deciding, therefore, that the child is entirely devoid of hearing, a physician may find, on examination, that it is too deaf to learn to talk in the ordinary way, in which case he should advise its parents to arrange for its proper education in another manner.

Advice is rarely sought respecting the aural condition of a child until, having come to an age when most children begin to use words intelligently, it arouses suspicion as to its peculiar defect, by showing no evidence of learning to talk.

It may be stated by the parents that they believe the child was, at one time, able to talk, because it has spoken such words as "mama or papa;" but the mere utterance of these elementary sounds of speech, which may occur entirely involuntarily in extremely young infants, is no evidence that the child hears. If there is reason to believe that the fears of the parents respecting the deficiency in the child are well grounded, a thorough examination of the ear should be made. If nothing abnormal can be discovered in the external or middle ear by inspection, or by inflation, and if the child has reached an age when it ought to talk, it may be concluded that it is too deaf to learn to talk by hearing others, and that, in all probability, its deafness cannot be relieved. If, however, on inspection an obstruction or deficiency in the sound-conducting parts is found, or if a suppuration exists in the ear, all such interferences to hearing should be combated in the ways already named in a previous part of this work. Without doubt some cases of deaf-muteness might be prevented by an early treatment of the local symptoms.

There is every reason to believe that very young children may be the subjects of chronic aural catarrh, which comes on insidiously, producing in them progressive hardness of hearing. While the same grade of hardness of hearing which has resulted in them, would not seriously impede an adult who had already

learned to talk, a child thus affected is too deaf to learn to talk by hearing others speak. I have found that mute children, in whom the membrana tympani showed signs of chronic aural catarrh, at the age of four and a half years, could hear the voice probably well enough to be taught to speak, when addressed by means of an ear-trumpet, if it were possible for any one in their family to undertake so laborious a method of instructing them.

Beyond combating a disease already firmly seated in the sound-conducting parts of the ear of a deaf mute, the surgeon can do nothing.

If the changes in these parts have not been of a deeply organic nature, the hearing may be benefited, and a portion of it retained. But if these changes have been of a structural nature, or have extended to the internal ear, little, if any, benefit to hearing can be hoped for. The only plea for treating a suppurative disease, which is not uncommon in deaf mutes, would be to prevent the *fatal* results of neglected otorrhœa.

While it is by no means the province of this book to describe or advocate any particular method of instructing deaf mutes, a word may be said respecting the methods which are usually employed.

In all civilized communities there are provisions for the proper corporeal, moral, and intellectual training of the deaf and dumb. Deaf mutes naturally communicate with each other by means of a sign-language which, in most respects, is common to all nations. This method, scientifically elaborated, is termed dactylology or finger-talking. Until within a few years it has been the usual mode of instructing deaf mutes in England and the United States.

The German system of educating mutes by teaching them to understand and use language, by observing and imitating the articulate speech of others, in which method the pupils are most positively forbidden to use the sign-language, has been employed for a long time in most of the countries of Continental Europe. An accurate and succinct account of this so-called German method may be found in a most interesting brochure on the subject, by Mr. W. B. Dalby.[1]

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[1] "Education of the Deaf and Dumb by means of Lip-reading and Articulation." By W. B. Dalby, F.R.C.S., M.D. (Cantab.), London, 1872.

Instances of mutes learning to understand what was said to them, by watching the lips of the speaker, are on record from the beginning of the eighth century, when John De Beverley, Archbishop of York, thus instructed an adult mute in the Christian religion, to the middle of the seventeenth century, when the book of John Bulwer induced John Wallis, of the University of Oxford, and William Holder, Canon of Ely and St. Paul's, to devote themselves to the education of the deaf and dumb by means of lip-reading.

It has also been practised in Spain and Italy between these two periods above alluded to, England, however, appearing to have been the pioneer in this mode of instruction, though among the last to give it an extended trial.

Heiniche, of Germany, in the middle of the eighteenth century, seems to have been the next notable advocate of instructing deaf mutes by lip-reading and articulation. It is now universally employed in that country.

In order to accomplish education by this means, the child must possess ordinary intelligence, normal vocal organs, and it must begin its studies in this direction at not later than seven years of age. The average length of time which must be given this course of education before the pupil can understand and communicate with any one he may meet, is about eight years.

But great attainments are thus made. It is a well-known fact that English mutes thus instructed have learned to talk not only their own language, but the French and German, and have become brilliant ornaments to society.

In Vienna, I have frequently conversed with deaf mutes in their own language, who attained such accuracy of observation of the lips of the speaker that they immediately perceived my foreign accent.

Bell's System of Visible Speech.—There is another means of teaching deaf mutes articulation, and that is the system of visible speech, or phonetic writing, of A. Melville Bell.

It is based on the physiological action and position of the vocal organs during speech, and is practically an alphabet of sounds, in which the symbols inform the child how to place its lips, tongue, and palate, and thus produce a vocal sound. It was successfully employed in England in 1869, since which time it has been introduced in several institutions in this country.

Lip-reading and visible speech may become of great value in the education of children who have become deaf after having learned to talk in the first four or five years of their life. Children of this age, who become entirely deaf in consequence of scarlatina, cerebro-spinal meningitis, or of any disease, will often voluntarily cease to talk, and thus, forgetting how to use speech, become mutes. I recall the case of an intelligent boy, six years old, who, becoming entirely deaf after cerebro-spinal meningitis, showed the greatest reluctance to talk, and relapsed at once into making signs, with the result of becoming mute. No matter how deaf a child may have become after it has learned to talk, it should be coërced to continue the use of speech, and *discouraged* in the use of signs. His conception of what speech is and his ability to use it are invaluable aids in his further education by means of lip-reading and articulation, or by visible speech.

Partially Deaf Children.—There is a large class of children, who are by no means deaf mutes, yet who hear so badly as to be under constant disadvantages at ordinary schools. Such children, on account of their poor hearing, are often imposed upon, both by their companions and their instructors; the former deceiving them, the latter misunderstanding them, and consequently losing patience with them. Do as they may, such pupils must fall behind.

It is not desirable for many reasons that children who have learned to talk, but who have become quite dull of hearing, should be isolated into separate classes; it is much better they should continue their studies with those among whom their lives are to be spent.

But allowance should be made for their defective hearing. This can only be accomplished by first ascertaining it. Many a child is hard of hearing without knowing its defect; it is, therefore, the place of its elders to find out and determine the amount of its deficient hearing.

That some special provision must be made for such children is fully justified by the statistics compiled by Dr. C. J. Blake, who has shown that out of 8715 cases of ear-disease, accompanied by impairment of hearing, 2175, or 25 per cent., were children under fourteen years of age, all of them pupils in the public schools.

In order that proper allowance be made for their defective

hearing, he has suggested that a careful examination "should be made in each case, to determine the degree of deafness as tested by the distance at which the voice of the teacher can be heard in ordinary conversation tone, and again by the pronunciation of consonant tones." These tests could be made by the teacher, and the following directions for making them are given: The teacher should always occupy, in testing the different cases, the same position, preferably the rostrum or seat usually occupied by him in school hours. He should speak in the same tone of voice used in the school-room exercises. The child to be tested should be placed in front of the teacher, and at the extreme limit of the farthest line of seats, and gradually advanced toward the teacher at certain intervals, the tests being repeated until a point is reached at which the child can hear distinctly. This point should determine the place the child should occupy in the school-room. The ears should be tested separately, the ear to be tested being turned toward the teacher, while the other is artificially closed. The child should be required to repeat distinctly the words as he hears them. The use of the voice in making tests of this kind was preferable to the use of watch, musical instruments, and the like, as being more applicable to the child's needs. The tests should be repeated when the child passes from one room to another, as the degree of deafness often varies at different ages. The examination of pupils by a medical expert was recommended as preferable, since an opinion of the nature of the aural disease and the mode of treatment could thereby be afforded the pupil. Dr. Blake strongly recommended the establishment of a medical supervisor of schools; the post to be occupied by a competent physician, who had made the matter of school hygiene a study, and his whole time to be devoted to the duties of his position.

Such a careful and scientific examination would reveal that some of the children were suffering from a disease of the ear, entirely amenable to treatment if taken at that time. They would, by thus being taken care of, not only regain hearing, and make more rapid advances in their studies, but they would often be enabled to get rid of a disease which would otherwise gradually grow worse, because unrecognized, and finally, becoming irremediable, render them permanently deaf. There is no greater fallacy in hygiene than that a child "will outgrow deafness."

Ear-Trumpets.—It has been proposed that the hopelessly hard of hearing use ear-trumpets. Such instruments are of most service when the defective hearing is due to a chronic catarrhal process in the middle ear, in which the ossicles and the membrana tympani are present. By a concentration of sound upon the conducting parts, the latter are in many instances made to perform their function better. If, however, the nerve is diseased, the concentration of sound by means of ear-trumpets will not be of much aid.

It has also been observed that, in cases of chronic suppuration with perforation and destruction of the drum-head, the use of the ear-trumpet is more apt to produce confusion and dizziness, than better hearing. No one form of ear-trumpet can be considered the best; each patient must be tried by a series of instruments, until one is found which proves of service to him.

It may be said most positively that all small, and so-called "invisible" ear-trumpets, or instruments to assist the hearing, no matter under what name they are vended, are *useless*, because they neither concentrate more sound upon the drum-head, nor increase the resonance of the external ear. In every instance all such instruments, which lie in the auditory canal, interfere with what little hearing may still exist. There is one exception, viz., in cases of hardness of hearing due to a collapse of the cartilaginous auditory canal, if such cases exist. Here, relief may be gained by holding the walls of the meatus apart by means of a small tube of some kind. Although I have never seen such a case, I am able to conceive that some instances of impaired hearing in old people may be due to such causes, after the loss of teeth, and the consequent alteration in the position of the under jaw, and the encroachment of its condyle upon the tissues of the external meatus of the ear.

I have heard of a case of hardness of hearing in an old woman, as relieved by the wearing of a complete set of artificial teeth, which, of course, would render the position of the under jaw normal, and thus relieve what probably has been called collapse of the auditory canal. Since in this case, the introduction of any instrument to hold the walls of the canal apart would have relieved the obstruction to hearing, it is possible to explain the vaunted triumphs of some small and *expensive* instruments, which at various times have been largely advertised.

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London, New Burlington Street.
July, 1877.

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